

# Biological Inventory Report for the Sonoran Desert Network: 2000 and 2001 Field Seasons



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## EXECUTIVE SUMMARY

This report summarizes the methods of data collection and results from the first field seasons of the biological Inventory and Monitoring (I&M) Program for the National Park Service Sonoran Desert Network (SODE) of parks. As recorded in Table 1, in 2000 and, to a greater extent, 2001 we surveyed for most taxa at five parks in Arizona and New Mexico. We surveyed for plants, reptiles and amphibians, birds, and mammals at Casa Grande Ruins National Monument (CAGR), Saguaro National Park (SAGU), Tonto National Monument (TONT), and Tumacacori National Historical Park (TUMA) in Arizona. We also surveyed for fish at TUMA. We surveyed for plants, amphibians, reptiles, birds, and mammals at Gila Cliff Dwellings National Monument (GICL) in New Mexico.

For CAGR, GICL, and TUMA, ours was the first-ever major inventory effort and, therefore, most species found were new for the parks. Even in parks with fairly complete lists, we documented notable numbers of new species. For example, at SAGU and TONT we found 35 and 28 new plant species, respectively. We also extended or clarified the geographic distribution and status of hundreds of species in all parks.

An important outcome of the program is the establishment and refinement of survey techniques for all taxa. For herps and mammals, especially, we scaled back or modified our study design to account for unforeseen field conditions. Our experiences will guide personnel of the monitoring program as they begin to think about the techniques and logistics of undertaking a large-scale field project.

This report is the first in a series of annual reports wherein we summarize data from our inventory effort. This preliminary report does not provide an exhaustive analysis of the data. Rather, we present data in a format that will immediately benefit park managers and interpreters; the results from most taxa are expressed as some derivation of relative abundance. For most taxa we discuss results by describing general patterns of species richness among and within parks and note species of interest. Data analysis is underway and we will provide personnel at each park, in 2003, with a more comprehensive description of the plants and vertebrates found in their parks.

**Table 1. Summary of field inventories in SODE parks.**

Park	Taxon					
	Plants	Amphibians	Reptiles	Birds	Fishes	Mammals
Casa Grande National Monument	✓	✓	✓	✓		
Gila Cliff Dwellings National Monument	✓	✓	✓	✓		✓
Saguaro National Park	✓	✓	✓	✓		✓
Tonto National Monument	✓	✓	✓	✓		✓
Tumacacori National Historical Park	✓	✓	✓	✓	✓	✓



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## INTRODUCTION

The primary mission of the U.S. National Park Service (NPS) is to protect some of America's greatest natural and cultural resources and to conserve them for future generations (NPS 1988). However, many parks have suffered environmental degradation, both directly as a result of management decisions inside the parks (National Research Council 1992), and indirectly due to land use changes outside of park boundaries. These changes often affect the numbers, diversity, or distribution of species in the parks.

The NPS and other federal and state agencies have often been criticized for their failure to prevent, or even recognize, the loss of species from public lands. These shortcomings are clearly shown by studies which report high extinction rates of mammals (Newmark 1995), amphibians (Drost and Fellers 1996), and plants (Drayton and Primack 1995, Turner et al. 1995) in parks, and are implicit in inventories and studies of park biodiversity (e.g., Cox and Franklin 1989, Debinski and Brussard 1994, Stohlgren et al. 1995a).

Basic biological information, including complete plant and animal species lists, is missing for most parks. As of 1994, more than 80% of national parks did not have complete inventories of major taxonomic groups (Stohlgren et al. 1995a). Inventory data is particularly lacking for smaller parks and for parks created to protect cultural resources, but which also include considerable natural resources. Responding to criticism that it lacked basic knowledge of natural resources within parks, NPS initiated its Inventory and Monitoring (I&M) Program in the early 1990s. The program was established to increase scientific research in national parks and detect long-term changes in biological or physical resources (NPS 1992).

Species inventories in national parks are important for a number of reasons. At one level, species lists are useful for interpretation and for visitor appreciation of natural resources. Knowledge of which species are present, particularly sensitive species, and where they occur is critical for making management decisions (e.g., locating new facilities, trails and prescribed fires).

Species inventories are also important for long-term monitoring. Good inventories provide both the basis for making monitoring decisions, such as which species and parameters to monitor, and the data for long-term monitoring of biological community characteristics such as species richness and distribution. Inventories can also be used to identify those species and communities that are most appropriate to monitor for changes in absolute abundance, demographic structure, or other individual or community parameters.

The purpose of our program is to complete basic inventories for vascular plants and vertebrates in the Sonoran Desert Network (SODE) of 11 parks in southern Arizona and southwestern New Mexico. From March 2000 to the present, we have been compiling data on plants and vertebrates at all of these parks. In December 2000, we evaluated the quality of data collected up to that point, identified information gaps, and determined priorities for field sampling for parks. In December of 2000 we produced the initial draft of our study plan (Davis and Halvorson 2000).

The goals of the inventory program are:

1. Compile historical data on all species of vascular plants and vertebrates believed to occur in SODE parks. Data are found in a number of formats, including museum records, voucher specimens, previous studies, and park databases. As we continue to collect data, we will input them into the appropriate NPS databases.
2. Complete field inventories with the goal of documenting at least 90% of all species of vascular plants and vertebrates estimated to occur in each park.
3. Gather inventory information using standardized techniques and repeatable designs so that our efforts can be repeated in the future to detect long-term changes in the distribution and abundance of species.
4. Provide park personnel with products that are useful for interpretation and management, including species lists, status assessments, and GIS-based distribution maps for species of interest.
5. Work closely with the monitoring personnel to assist them in developing protocols and a framework for monitoring plants and vertebrates.

This biological inventory report is the first in a series of reports that will track our progress toward reaching these goals.

## PARK INFORMATION

In accordance with the study plan (Davis and Halvorson 2000), we initiated field inventories in five parks in the SODE in 2000 and 2001. Parks are shown on Figure 1 and described below. Park climate data are found in Table 2.

### Casa Grande Ruins National Monument

Casa Grande Ruins National Monument (CAGR) protects the Casa Grande and other ruins of the ancient Hohokam culture. It was the first designated prehistoric and cultural site in the U.S. (1892) before becoming a national monument in 1918. The park contains 191 ha of desert scrub vegetation with scattered mesquite woodland remnants. CAGR has a base elevation of 430 m and little topographic relief. The rural lands once surrounding the park are now being developed as the town of Coolidge, Arizona grows.

### Gila Cliff Dwellings National Monument

Gila Cliff Dwellings National Monument (GICL) is located in the highlands of western New Mexico and is surrounded by the Gila National Forest and extensive wilderness areas. The park was established to protect well-preserved 13<sup>th</sup> century cliff dwellings. The park consists of two units, the larger cliff dwellings unit and the TJ ruins unit, located a short distance from the visitors center. Vegetation communities at or near this 216-ha park include Madrean evergreen woodland, pine forests and riparian association.

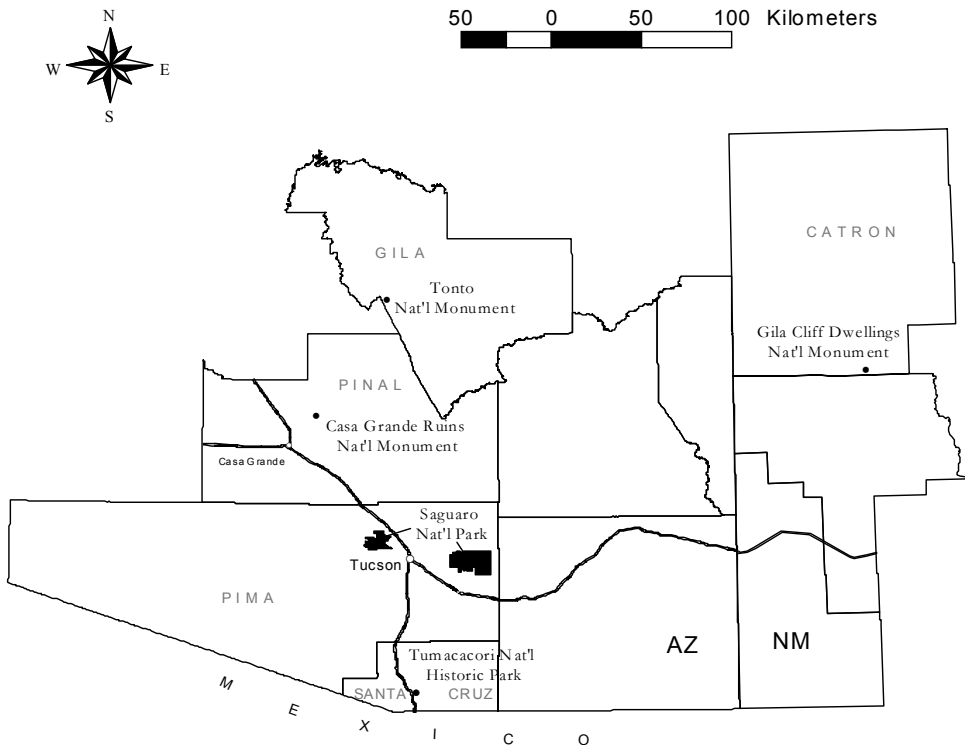


Figure 1. Map of Sonoran Desert Network parks that had biological inventories in 2000 and 2001.

**Table 2. Climate information for SODE parks.**

Park	Mean daily temperature in July (° C)	Mean daily temperature in January (° C)	Mean Annual Precipitation (cm)
CAGR <sup>a</sup>	32.6	9.2	18.9
GICL <sup>a</sup>	21.2	1.4	41.1
SAGU E – low elevation <sup>b</sup>	30.2	10.9	33.1
SAGU E – high elevation <sup>c</sup>	18.1	1.4	79.3
SAGU W <sup>a</sup>	30.7	11.9	34.4
TONT <sup>a</sup>	29.7	7.2	40.5
TUMA <sup>a</sup>	26.5	7.3	40.9

<sup>a</sup> Arizona and New Mexico climate reports (2002).

<sup>b</sup> Arizona and New Mexico climate reports (2002). Data from Sabino Canyon in the adjacent Santa Catalina Mountains.

<sup>c</sup> Arizona and New Mexico climate reports (2002). Data from Pallasades Ranger Station in the adjacent Santa Catalina Mountains.

### **Saguaro National Park**

Saguaro National Park (SAGU) was established in 1933 to protect saguaro cacti (*Carnegiea gigantea*) on the lower slopes of the Rincon Mountains (Rincon Mountain District; SAGU E). The Tucson Mountain District (SAGU W), west of Tucson, was added in 1961 because of alarm about the lack of saguaro recruitment in SAGU E. SAGU W consists chiefly of Sonoran desert uplands and SAGU E contains five life zones: Sonoran desert uplands, grasslands, oak woodlands, pine forests, and mixed conifer forests. The biggest natural resource issue at this 41,300-ha park is urban expansion adjacent to its boundaries; Tucson is one of the fastest growing cities in the United States and some development now touches park boundaries. For the purposes of this report, we generally analyzed each district separately.

### **Tonto National Monument**

Tonto National Monument (TONT), established in 1907 and encompassing 453 hectares, was set aside to protect two prehistoric Salado cliff dwellings and associated sites. TONT consists mainly of Sonoran desert upland vegetation communities, with some localized spring-fed riparian vegetation. The park is surrounded by USDA Forest Service land. Recent improvements in recreational facilities for neighboring Roosevelt Lake continue to increase visitation to the Tonto Basin.

### **Tumacacori National Historical Park**

Tumacacori National Historical Park (TUMA) was established in 1908 to preserve the San José de Tumacacori Mission which was established in 1691. In 1990 the nearby mission ruins of Guevavi (established in 1691) and Calabazas (established in 1756) were added to the park. Sonoran desert riparian scrub and some mesic riparian communities along the Santa Cruz River (SCR), inhabit the three units. The SCR adjacent to the Mission unit has perennial water because of a wastewater treatment facility located a few kilometers upstream of the area. At the time of this writing, there is a bill before the U.S. Congress that will expand the Mission unit by 1400% through acquisition of private lands, which are located adjacent to the Mission site in the biologically-rich riparian area along the SCR.

## SPATIAL SAMPLING DESIGNS

Our effort is the first of its kind in the southwest: an inventory of multiple areas (parks) using a design that can, if repeated, detect changes in the numbers or distribution of plants and animals. We designed the study so that we could apply results to most areas within larger parks by randomly allocating sampling units. For smaller parks, our spatial sampling designs varied from randomly located study sites, to preferentially selected areas, to complete coverage of the park. In some parks we employed more than one spatial sampling method. This section provides a brief overview of the major spatial designs (for more detail, refer to Davis and Halvorson 2000).

### **Stratified Random Design: SAGU E only**

Differences in plant and animal communities occur at different elevations zones in mountainous areas. To account for these differences, we used a stratified random design using elevation to delineate three strata (<4000; 4,000-6,000; and >6,000 feet) when sampling in the Rincon Mountains within SAGU E. We chose a stratified design over a simple random design because stratified sampling better captures the inherent environmental variability within strata, allowing for greater precision of parameter estimates and increased sampling efficiency (Levy and Lemeshow 1999). This design also generates a better spatial dispersion of sampling units. We chose to delineate strata based on elevation because it can be a good predictor of changes in vegetation and animal communities and is especially useful when no reliable vegetation maps exist, as was the case in SAGU E.

Once we delineated and mapped strata using existing GIS datasets, we used a multi-level sampling design to survey for major taxa. First, we excluded unsafe or inaccessible areas based on digital elevation models in ArcView GIS. Within each stratum, all surveyable areas had an equal probability of being chosen for location of **focal points**, the reference points from which we surveyed for all taxa (except fish, which are not found in SAGU). From focal points we surveyed for plants and vertebrates at **secondary units** (grids, plots, points or transects) that we placed along a transect (herein referred to as **focal-point transect [FPT]**). Each FPT originated at the focal point and went for 1 km in a random direction. For a description and layout of secondary units, see the methods sections for each taxa.

This design offers a numbers of strengths. First, there is a random component in choosing the location of focal points, which allows inferences within each stratum. Second, environmental characteristics measured at each focal point can be used for monitoring concomitant changes in animal and plant communities.

### **Simple Random Design**

For CAGR, GICL, SAGU W and TUMA, the relative lack of extreme changes in elevation and plant and animal communities permitted the use of a simple random rather than stratified random design. We treated each of these parks as a single stratum. This design has the same strengths as the stratified random design provided there is relative homogeneity of environmental variables within each park or unit.

### **Preferential Selection of Study Sites**

Most parks contain unique areas requiring special surveys for most taxa. Riparian areas, cliffs, rocky outcrops and ephemeral pools were likely to be missed if we located our study sites only in

random areas. Yet these areas are diversity “hotspots” and are therefore crucial to visit in order to complete the species inventories. We selected preferential study areas based on our knowledge of the taxa and parks. An important consideration of this design is that the results of these surveys do not apply outside of the areas sampled.

### **Complete Coverage**

For small parks it was possible to survey the entire area for certain taxa without selecting study sites. From a sampling design perspective, this is an ideal situation in that there are no issues about inference; the entire “universe” (i.e., the park) is covered.

## PLANTS

### METHODS

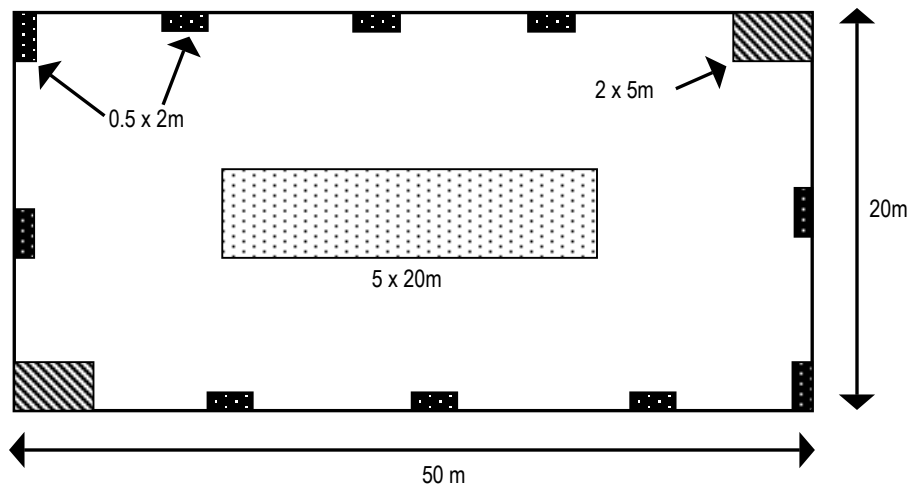
We used four methods to survey for plants

1. Modified-Whittaker plots at most FPTs at SAGU
2. Line-intercept transects along all FPTs at SAGU
3. Special area searches at SAGU
4. Walking surveys/incidental sighting reports at all parks

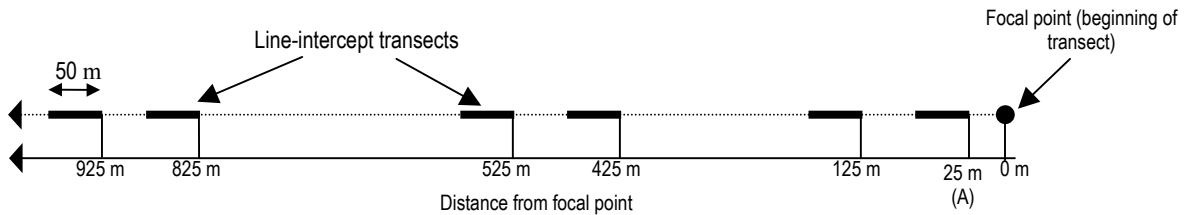
#### Modified-Whittaker Plots

We used modified-Whittaker plots to facilitate comparison of floras at FPTs. Figure 2 shows the layout of these 1000-m<sup>2</sup> rectangular plots containing 13 nested subplots of three different sizes (see Stolgren et al. 1995b). We recorded all perennial plant species and their coverage in square meters for the entire 1000-m<sup>2</sup> plot. Shmida (1984) explains the data collection methods in detail. We deviated from Shmida's method somewhat by not surveying against the contours in steep areas for obvious practical reasons. We also sampled with Braun-Blanquet Relevés, individual circular 1000-m<sup>2</sup> plots used in many studies (Mueller-Dombois and Ellenberg 1974). After comparing the two methods, we determined that the modified-Whittaker plots better captured plant species richness and allowed us to calculate species-area curves. Also, they are used commonly by federal agencies, and so allow for comparisons with a greater number of studies.

Figure 2. Layout of modified-Whittaker plot for vegetation sampling at SAGU.







**Figure 3.** Typical layout of line-transects for vegetation sampling along FPTs at SAGU. Line-intercept transects were 50-m long and the first transect began 25 m in from the focal point (A).

### **Line-intercept Transects**

We used the point-intercept method (Bonham 1989) to sample vegetation along six 50-m transects located along each FPT (Fig. 3). Line-intercept transects began at 25, 125, 425, 525, 825 and 925 m from the focal point. For example, the first transect started at 25 m from the focal point and went to the 75 m mark. We measured density and composition of perennial vegetation by recording the species of any vegetation that came in contact with a 4-m pole along three height categories (0-0.5; 0.5-2; 2-4 m). Due to our inability to carry longer poles, we visually extrapolated contacts in a fourth height category (> 4 m), which was rarely used in the desert areas. We classified groundcover as rock, bare ground, annual forb, grass or woody debris.

We will use cover type, vegetation density and species composition along the transects to describe “habitat” characteristics for the vertebrates and to monitor vegetation structure and composition.

### **Complete Coverage**

At all parks except SAGU, we walked the entire park, unit, or area of interest using a systematic walking pattern. We surveyed specifically to complete species lists for the parks.

#### **Casa Grande Ruins National Monument**

We visited CAGR on March 22 and 23, 2001. We walked most of the park, but concentrated our effort in areas of high vegetation density. Patty Guertin shared species locations from her collecting for the USGS Sonoran Desert Field Station.

#### **Gila Cliff Dwellings National Monument**

We visited all areas of both units in mid-May and mid-August 2001. In addition, Emily Bennett collected specimens from May through September 2001 while working on another project.

#### **Tonto National Monument**

We visited TONT from July 24 to 27, 2001. We concentrated on the riparian area and, at the urging of park staff, we visited areas adjacent to highway 88, residential and picnic areas, trail to the lower ruin and saddle east and hillsides southwest of the visitors center.

#### **Tumacacori National Historical Park**

We walked all areas within each of the three TUMA units on 15 visits each to the Mission and Guevavi units, and 14 visits to the Calabasas unit. We surveyed approximately every 10 to 30 days from August 2000 through October 2001.

### Vouchers and Identification

We collected plant specimens for species that had not been collected in the parks previously. Additional collections were made of unknown plants in order to identify them later in the UA Herbarium. At the site of plant specimen collection, we recorded flower color (if applicable), UTM coordinates, and general vegetation type. We identified all specimens according to the ITIS (Integrated Taxonomic Information System 2002), the most current web-based authority for plant nomenclature.

### RESULTS

We collected 1,918 plant specimens at SODE parks in the 2000 and 2001 field seasons (Table 3). We collected the most specimens and species at SAGU E, followed by TUMA and GICL. We collected 345 new records for the all the parks; numbers ranged from 171 at GICL to 4 at SAGU W. The percentages of non-native new species found were highest at TUMA (23%) and TONT (21%), and zero at SAGU W.

We are continuing to identify voucher specimens and to analyze the modified-Whittaker plots and line-intercept data and will report those findings in our final report to parks. Because of the length of plant lists for most parks, we are preparing, as an attachment to this report, a list of species for each park.

**Table 3. Summary of preliminary results from plant specimen collecting at SODE parks, 2000 and 2001.**

Park	Number of specimens collected	Number of species	Number of new records for the park	Number of new records that are non-native	Percentage of new records that are non-native	Attachment
CAGR	59	52	24	4	17	A
GICL	374	280	171	16	9	B
SAGU E	750	493	35	6	17	C
SAGU W	99	81	4	0	0	C
TONT	206	172	28	6	21	D
TUMA	430	350 <sup>a</sup>	83	19	23	E
<b>Totals</b>	<b>1918</b>	<b>1428</b>	<b>345</b>	<b>51</b>	<b>15</b>	<b>NA</b>

<sup>a</sup> Approximate number.



At each plot a single observer recorded weather information (temperature, relative humidity, percent cloud cover, wind speed, and an overall description of the conditions), then surveyed each plot for 60 minutes. For each herp observed, we recorded species, time of observation, method used to find the animal (visual, heard rustling sound, scanning with binoculars, moving cover, using mirror, or other), microhabitat characteristic of the area where the animal was located (bare ground, vegetation, rock, edifice, burrow, or water), sex and age (if known), activity the animal was engaged in when it was first encountered, and behavior the animal displayed after it was observed (moving, escaping, basking, hiding, displaying, feeding, resting or other).

We used Garmin Emap GPS units to trace our search path and to make sure we stayed within the plot during the search. We recorded weather information again at the end of each plot survey and wrote a short “habitat” description of the plot. Also, we estimated the percentage of time we spent searching using the various observation methods.

After July 31, we stopped surveying at FPTs because of the low numbers and diversity of animals observed (i.e., it was not efficient). Instead, we focused most of our effort in special areas (described below).

### **Extensive Surveys**

FPTs were not likely to include areas that support a high diversity of herps, because these areas are rare and are unlikely to be included in a random sample of the park. Therefore, we used extensive surveys (ESs) in areas near FPTs that were likely to have a higher diversity of herps to augment observations made at the random plots. While two researchers were surveying at FPTs, a third person surveyed at the nearby extensive area. This person traveled to the focal point with the rest of the crew, then identified an area that might have high diversity of herps, typically a canyon, riparian area, ridgeline, or cliff face.

ESs typically lasted for the duration of the FPT surveys. We recorded the same data about the weather and each herp observed as described above in the previous section (Focal Point Transects). In addition, we gave each herp a number and plotted its location on a topographic map of the search area. We documented the boundaries of our search area or the path we followed during our survey, using UTM coordinates.

FPT and ES duties were rotated among the three-person crew. Extensive surveys were discontinued after July 31 when we stopped surveying at FPTs.

### **Plot Surveys**

For CAGR, GICL, and TUMA we surveyed for herps using a variation on FPTs. We located plots in representative biotic communities within the study areas. For GICL and TUMA we also established plots on lands adjacent to the parks. For all three parks we recorded the same weather and data on animals as at FPTs.

### Casa Grande Ruins National Monument

We divided the park into a grid of 48 plots (eight east-to-west, six north-to-south), each measuring 200 x 200 m. We surveyed a random set of 24 plots in the mornings and five plots at night. We visited each plot once. During the spring, one person was typically able to survey two plots in a morning before lizard activity decreased significantly due to high temperatures.

However, during the summer, there was usually only time for each person to survey one plot per morning.

#### Gila Cliff Dwellings National Monument

We established 15 plots within the study area: six plots within the primary unit of the park, three in the TJ ruins unit, and six on USDA Forest Service lands adjacent to the park. Of the 15 plots, 13 measured 100 x 100 m. The remaining two were in steep-sided Cliff Dweller Canyon. On those plots we selected two points and surveyed the area between those points. During the spring survey (May 26-30) we visited all plots, but during the summer survey (August 21-23), guided by our experience in the first trip, we surveyed only the four plots that were most likely to have the highest diversity.

#### Tumacacori National Historical Park

We established fifteen 100 x 100 m plots at TUMA: one at the Mission site, 11 on private land adjacent to the Mission, two at Calabasas, and one at Guevavi. We surveyed plots for one hour in the mornings. During the spring (April 24-27) we surveyed all plots, but during the summer (September 9-10) we surveyed seven plots.

#### **Special-area Surveys**

We designed special area surveys (SASs) to enable us to search areas that we determined, based on our experience, were likely to have a high diversity or abundance of herps, or a particular species of interest. We also wanted a more flexible survey technique that would increase the number of species found. At SAGU, after July, we concentrated most of our effort on SASs, which we also used at the other four parks.

The majority of SASs are located in major canyons and riparian areas, but our selection criteria varied among parks because of differences in size and habitat features. For example, at SAGU we targeted major drainages, at CAGR we usually searched the entire park, and at TONT we searched only the riparian area.

We used similar survey methods and data recording procedures as for FPTs and ESs. The main difference between SASs and ESs was that during SASs, all crew members, rather than one individual, often searched the same area together. Also, we conducted SASs at all times of the day and night, and search times varied from approximately one to seven hours.

#### **Pitfall Traps**

We used one pitfall trap at each of three parks: CAGR (100 m north of the park entrance road and approximately 600 m west of the park entrance), SAGU W (west of Sandario Road and south of Manville Road), and TUMA (on private land near the bank of the Santa Cruz River).

We constructed the traps using four 5-gallon buckets. We placed three buckets 8 m away from a central bucket in a horizontal plane at angles of about 120 degrees (Fig. 5) (Gibbons and Semlitsch 1981). We buried the buckets in the ground so that the lip of each bucket was at ground level, then dug a shallow trench connecting each of the three outside buckets to the central bucket. We placed a drift fence consisting of a 7.6-m length of (white) aluminum flashing in each trench, filled in the trench, and supported each wall with rebar.

An animal encountering one of the drift fences would turn right or left to go around it. Upon reaching the end of the fence, an animal would fall into the bucket and be unable to escape.

We typically opened the pitfall traps around sunset, then checked and closed the traps with tight-fitting lids early the next morning. Cover boards erected a few inches above the buckets helped to keep the animals cool during the day. We used funnel traps (made of wire mesh) to capture snakes large enough to crawl out of the pitfall trap buckets. We used six funnel traps at each site, and wedged each funnel trap behind rebar at the midpoint of each side of each wall. The number of nights the traps were open varied by site: 13 at CAGR, 9 at SAGU W, and 20 at TUMA.

### Road-cruising Surveys

We used road-cruising surveys at GICL (along the road from the visitors center to the Cliff Dweller Canyon trailhead), SAGU E (Loop Road) and SAGU W (Kinney, Hohokam, and Golden Gate Roads). Road cruising involves driving slowly along a road, typically after sunset, and watching the road and shoulder for animals. During these surveys we recorded the same weather



Figure 5. Photos of pitfall array at TUMA showing five-gallon bucket (A) at the center of three 7.6m-long sheets of aluminum flashing (B). Photos by D. Prival.

information at the beginning and end of the survey that we recorded during other surveys. When we encountered an animal, we recorded the species, time observed, the mileage from the start point of the survey, and whether the animal was alive or dead. At SAGU E and W, we recorded the appropriate section of road based on the road cruising map created by SAGU staff.

### **Incidental Observations**

When we were not conducting a formal survey, we recorded each herp we saw and the time of observation, and assigned the animal a letter (starting with A). We then plotted the corresponding letter on a topographic map. We also recorded the route we were taking when we saw the herp.

To assign each incidental observation to a geographic location, we created a grid and superimposed it over a map of each park using ARCVIEW. We then determined where each herp was seen and used the center point of each grid square to determine the approximate location of each herp. We recorded the incidental location of herps in SAGU E using a 400 x 400 m square and in the other parks or units, including SAGU W, using grids of 100 x 100 m squares. These data will be used to create distribution maps for each species.

### **Voucher Specimens and Photographs**

We collected voucher specimens and photographs throughout the field season. For each voucher specimen, we recorded the species, where and when it was collected, and who collected it. Prior to field work, we collected records of voucher specimens from several parks and the UA collection to create a list of species that had already been collected from each park. When we found a species that was not on the voucher list or we found a dead animal in reasonable condition, we usually turned it into a specimen. We deposited voucher specimens in the UA reptile and amphibian museum collection. The only park from which we did not collect voucher specimens is CAGR, a small park surrounded by agricultural fields and shopping malls. For some species a single animal could represent a significant percentage of the population within the park.

We photographed, using slide film, every herp species that we were able to capture. We recorded the same information for each voucher photograph that we recorded for voucher specimens. We labeled each slide to indicate the species, date, park, and name of the photographer. We selected between one and three slides as official voucher photographs for each species.

## **RESULTS**

We found 11 species of amphibians and 51 species of reptiles during the 2001 field season (Tables 5 and 6, respectively). We found the highest diversity of herp species at SAGU E and the fewest at TONT. Similarly, the total number of individuals found was highest at SAGU E (1362) and lowest at TONT (83). These differences are not surprising given the diversity of biotic communities in SAGU E and the limited search area at TONT.

The most abundant amphibian species at each park unit were the Colorado River toad at CAGR, the non-native American bullfrog at GICL, the red-spotted toad at SAGU W, the canyon treefrog at SAGU E, and the Couch's spadefoot and Great Plains toads at TUMA; we found no amphibians at TONT (Table 5).

The most abundant reptiles species at each park were the common side-blotched lizard and tiger whiptail at CAGR, the ornate tree and eastern fence lizards at GICL, the zebra-tailed lizard at SAGU W, the ornate tree lizard at SAGU E, the ornate tree lizard and common side-blotched lizard at TONT, and the Sonoran spotted whiptail at TUMA (Table 6).

The Colorado river toad, which was found at four of the park units, was the most widespread amphibian encountered in our survey, while four amphibian species were found in only one park unit (Table 5). In the six park units, we found one species of reptile (gophersnake) in all, one species (ornate tree lizard) in five, one species (coachwhip) in four, and 21 reptile species that were unique to a single park unit (Table 5).

The data for amphibians and reptiles include results from all survey methods combined. In the coming months we will analyze data from each survey technique, then present those data in the final report to each park. These analyses will give managers and interpreters a more precise estimate of the relative abundance of herp species in their parks.

We took 200 official voucher photographs of herps at all parks except TONT, which already has an extensive photo voucher collection. SAGU E had the most species with voucher photographs (Table 5). We are in the process of scanning these slides, and the digital images will be available for use by park personnel.

**Table 5. Relative frequency (%) of observations of amphibians by park unit, 2001. Frequencies were calculated using total numbers of individuals from all sampling methods. Underlined numbers indicate that photographic vouchers were obtained.**

Order	Percent Relative Frequency for Park Unit								
	Family	Scientific name	Common name	CAGR	GICL	SAGU W	SAGU E	TONT	TUMA
Anura									
Pelobatidae	Scaphiopus couchii	Couch's spadefoot toad				4.35	1.31		46.78
	Spea multiplicata	Mexican spadefoot toad							1.17
Bufonidae	Bufo alvarius	Colorado river toad	100.00			13.04	14.18		1.17
	Bufo cognatus	Great Plains toad				2.17			42.11
	Bufo microscaphus	Arizona toad			35.92				
	Bufo punctatus	red-spotted toad				80.43	19.22		
	Bufo woodhousii	Woodhouse's toad							1.17
Microhylidae	Gastrophryne olivacea	Great Plains narrow-mouthed toad							0.58
Hylidae	Hyla arenicolor	canyon treefrog			2.11		41.79		
Ranidae	Rana catesbeiana	American bullfrog			61.97				7.02
	Rana yavapaiensis	lowland leopard frog					23.51		
Total number of individuals				12	142	46	410	0	171
Species richness				1	3	4	5	0	7
Number of species with photo vouchers				1	3	4	5	0	7



**Table 6. Relative frequency (%) of observations of reptiles by park unit, 2001. Frequencies were calculated using total numbers of individuals from all sampling methods. Underlined numbers indicate that photographic vouchers were obtained.**

Order	Family	Scientific name	Common name	Percent Relative Frequency for Park Unit					
				CAGR	GICL	SAGU W	SAGU E	TONT	TUMA
Testudines									
	Emydidae	<i>Terrapene ornata</i>	ornate box turtle						0.18
	Kinosternidae	<i>Kinosternon sonoriense</i>	Sonora mud turtle				1.87		0.18
	Testudinidae	<i>Gopherus agassizii</i>	desert tortoise			0.61	0.91		
Squamata									
	Teiidae	<i>Cnemidophorus burti</i>	canyon spotted whiptail lizard				0.28		
		<i>Cnemidophorus exsanguis</i>	Chihuahuan spotted whiptail lizard		9.52				
		<i>Cnemidophorus flagellicaudus</i>	Gila spotted whiptail lizard				2.82		
		<i>Cnemidophorus sonorae</i>	Sonoran spotted whiptail lizard			0.99	10.69		52.61
		<i>Cnemidophorus tigris</i>	tiger whiptail lizard	41.41		17.97	3.38		
		<i>Cnemidophorus uniparens</i>	desert grassland whiptail lizard						17.84
	Anguidae	<i>Elgaria kingii</i>	Madrean alligator lizard		0.85		0.24	1.20	
	Scincidae	<i>Eumeces obsoletus</i>	Great Plains skink				0.04		
	Gekkonidae	<i>Coleonyx variegatus</i>	western banded gecko	3.13		1.29	0.60	1.20	
	Helodermatidae	<i>Heloderma suspectum</i>	Gila monster			0.83	0.87		
	Iguanidae	<i>Callisaurus draconoides</i>	zebra-tailed lizard			40.03	4.29		
		<i>Cophosaurus texanus</i>	greater earless lizard				4.45	2.41	
		<i>Crotaphytus collaris</i>	eastern collared lizard		0.17	0.15	0.83		
		<i>Dipsosaurus dorsalis</i>	desert iguana			0.91			
		<i>Gambelia wislizenii</i>	long-nosed leopard lizard			0.23			
		<i>Holbrookia maculata</i>	common lesser earless lizard			1.44	0.24		1.98
		<i>Phrynosoma hernandesi</i>	greater short-horned lizard		0.34		0.56		
		<i>Phrynosoma solare</i>	regal horned lizard			0.83	0.24		0.54
		<i>Sceloporus clarkii</i>	Clark's spiny lizard			4.32	12.52		5.95
		<i>Sceloporus magister</i>	desert spiny lizard	1.72		2.96	1.63		
		<i>Sceloporus poinsettii</i>	crevice spiny lizard		4.93				
		<i>Sceloporus undulatus</i>	eastern fence lizard		34.52		9.02		2.16
		<i>Urosaurus graciosus</i>	long-tailed brush lizard	3.75					
		<i>Urosaurus ornatus</i>	ornate tree lizard		44.56	6.82	28.93	42.17	15.68
		<i>Uta stansburiana</i>	common side-blotched lizard	45.00		12.05	5.21	40.96	
	Leptotyphlopidae	<i>Leptotyphlops humilis</i>	western threadsnake			0.08			
	Viperidae	<i>Crotalus atrox</i>	western diamondback rattlesnake	0.16		4.25	2.42		0.72
		<i>Crotalus cerastes</i>	sidewinder			0.08			
		<i>Crotalus molossus</i>	black-tailed rattlesnake		0.34	0.23	0.76		
		<i>Crotalus scutulatus</i>	Mojave rattlesnake	0.63		0.15			
		<i>Crotalus tigris</i>	tiger rattlesnake			0.53	0.68		
		<i>Crotalus viridis</i>	western rattlesnake				0.87		
	Colubridae	<i>Arizona elegans</i>	glossy snake			0.08			
		<i>Hypsigena torquata</i>	nightsnake			0.15	0.04		0.18
		<i>Lampropeltis getula</i>	common kingsnake	0.16			0.08		
		<i>Lampropeltis pyromelana</i>	Sonoran mountain kingsnake				0.08		

Order	Family	Scientific name	Common name	Percent Relative Frequency for Park Unit					
				CAGR	GICL	SAGU W	SAGU E	TONT	TUMA
		<i>Masticophis bilineatus</i>	Sonoran whipsnake				<u>0.72</u>		
		<i>Masticophis flagellum</i>	coachwhip	0.16		<u>1.06</u>	0.36		<u>0.90</u>
		<i>Masticophis taeniatus</i>	striped whipsnake		0.17				
		<i>Pituophis catenifer</i>	gophersnake	<u>0.47</u>	<u>0.85</u>	<u>0.38</u>	<u>0.20</u>	2.41	0.36
		<i>Rhinocheilus lecontei</i>	long-nosed snake	<u>3.44</u>		<u>0.99</u>	<u>0.16</u>		<u>0.36</u>
		<i>Salvadora grahamiae</i>	eastern patch-nosed snake		0.17		<u>0.04</u>		
		<i>Salvadora hexalepis</i>	western patch-nosed snake			<u>0.38</u>	<u>0.12</u>		
		<i>Sonora semiannulata</i>	groundsnake				<u>0.04</u>		
		<i>Tantilla hobartsmithi</i>	Smith's black-headed snake						<u>0.36</u>
		<i>Thamnophis cyrtopsis</i>	black-necked gartersnake		<u>1.19</u>		<u>3.78</u>		
		<i>Thamnophis elegans</i>	terrestrial gartersnake		<u>2.38</u>				
	Elapidae	<i>Micruroides euryxanthus</i>	Sonoran coral snake				<u>0.04</u>		
<b>Total number of individuals</b>				<b>640</b>	<b>588</b>	<b>1319</b>	<b>2516</b>	<b>83</b>	<b>555</b>
<b>Species richness</b>				<b>11</b>	<b>13</b>	<b>27</b>	<b>37</b>	<b>7</b>	<b>15</b>
<b>Number of species with photo vouchers</b>				<b>10</b>	<b>11</b>	<b>25</b>	<b>35</b>	<b>0</b>	<b>14</b>

## BIRDS

### METHODS

We surveyed birds during the 2001 field season using three methods: variable circular-plot method for diurnal birds, nocturnal surveys for owls and nightjars, and incidental observations for all species. We chose to concentrate our efforts during the breeding season for two reasons. First, breeding habitat plays a key role in the lifecycle of animals. Second, and most importantly from a monitoring perspective, the distribution of birds are sporadic and/or clumped during the non-breeding season due to the lack of territoriality. However, during the breeding season birds maintain territories, thereby increasing our precision in estimating parameters that we are interested in monitoring such as abundance or density. It is important to note, however, that we are also surveying during the peak time of migration through our study area for most species, thereby adding to our species lists.

#### Variable Circular-plot Method: Diurnal Surveys

To survey for diurnal birds, we used the variable circular-plot method (VCPM)(Reynolds et al. 1980; Buckland et al. 1993). Table 7 shows the location and description of the 36 transects that we

**Table 7. Number and description of bird transects and points at SODE parks, 2001.**

Survey Type	Park	Transect name or description	Number of transects	Total Points
<b>Diurnal</b>	CAGR	CAGR	1	12
	GICL	Uplands- near ruins	1	6
		Riparian- West fork Gila River	1	6
	SAGU E	Low-elevation random	5	20
		Mid-elevation random	7	28
		High-elevation random	5	20
		Lower Rincon Creek	1	8
		Upper Rincon Creek	1	4
		Box Canyon	1	7
		Happy Valley Saddle	1	6
		Lower Rincon Creek	1	8
		Upper Rincon Creek	1	4
		Rincon Peak	1	4
		Loma Verde Creek	1	2
	SAGU W	Random	5	20
		King's Canyon	1	1
	TONT	Riparian area	1	6
	TUMA	Mission and adjacent lands	1	8
<b>Totals</b>			<b>36</b>	<b>170</b>
<b>Nocturnal</b>	CAGR	Main Road	1	4
	GICL	Main Road	1	4
	SAGU E	Loop Road	1	5
		Rincon Creek	1	6
		Cowhead Saddle	1	4
		Manning Camp	1	4
		Happy Valley Saddle	1	3
	SAGU W	Golden Gate	1	6
		Loop Road	1	6
	TONT	Riparian area	1	6
	TUMA	Mission and adjacent lands	1	3

Totals	11	45
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established in 2001. At each FPT we established four points (Fig. 6) and from one to 12 points at special areas. The spacing between all points was a minimum of 250 m and at FPTs the first and last points were 125 m in from the end of the transect.

A crew of three observers surveyed from early April to late July, the period of peak breeding activity for most species in southern Arizona. To account for the later onset of breeding at higher elevations (at GICL and SAGU E), we began surveying low-elevation areas first and moved to progressively higher elevations as conditions permitted. We surveyed most transects four times with a minimum of ten days between surveys. On each visit, we alternated observers and the order in which we surveyed points along a transect to minimize observer bias.

We began surveying birds from a few minutes before, to no later than four hours after, sunrise or when bird activity decreased markedly. We did not survey during gusty winds, when the average wind speed exceeded approximately 15 kph or when precipitation was heavier than an intermittent drizzle.

We recorded a number of environmental variables before we began each transect: wind speed (using Beaufort scale), whether it had recently rained, temperature (°C), humidity (using a gauge) and cloud cover. Once at a point, we waited one full minute before beginning the count to allow birds to resume their normal activities. During the “active” period we counted birds for 8 minutes and identified birds to species. We then recorded the exact distance (in meters) to each bird (often with the aid of laser range finders), time of detection (measured in one-minute intervals beginning at the start of the active period), and, if known, the sex and age class (adult or juvenile) of the bird(s). When observed, we recorded breeding behavior. We did not estimate distances to birds that were flying. We recorded an individual as a “repeat” if we recorded it on a previous point in the transect. If we detected a species during the “passive” count period (anytime other than during the eight-minute count) we recorded its distance to the nearest point.

**Tape-playback for Owls**

To inventory for owls we used tape-playbacks (Bibby et al. 1992) whereby we broadcast a recording of the species of interest using a megaphone setup (CD player and broadcaster). The owl recordings were from commercially available CDs (Peterson’s Western Birds and Stokes Field Guide to Bird Songs- western edition). Although we did not broadcast calls of nightjars, we recorded when we heard them during owl surveys and at other times.

We attempted to survey each transect at least three times during the breeding season, with a minimum of ten days between surveys. We established at least one owl survey transect along a road or trail at each park (Table 7). Owl call points were a minimum of 300 m apart and the number of points varied from three to six per transect. As with the VCPM surveys, we began surveying in the low-elevation

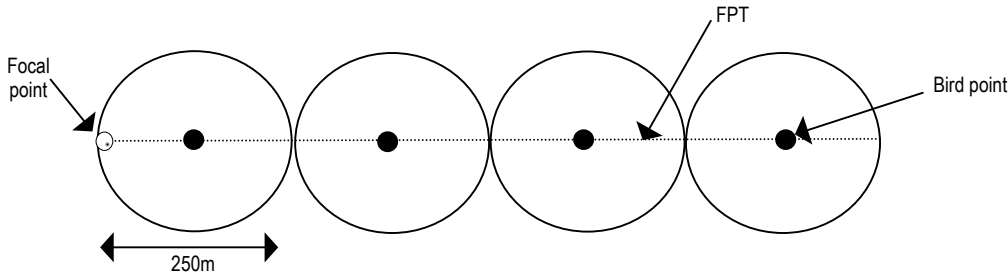


Figure 6. Layout of diurnal bird points along a FPT with 250 m between points.

transects early in the season and moved to progressively higher transects as conditions permitted. We also alternated observers and direction of travel along transects. We began surveys 45 minutes after sunset.

At each point, we began with a three-minute “passive” listening period when we broadcast no calls. We then broadcast recordings of four to six owl species, each with its own two-minute “active” period. During active periods, we broadcast owl calls for 30 seconds followed by a 30-second listening period. This pattern was repeated two times for each species. We played recordings of owls, in order, from the smallest to the largest-sized species so that smaller species would not be inhibited by the “presence” of larger predators or competitors (Fuller and Mosher 1981). For example, at SAGU W, we broadcasted for elf, western-screech, burrowing and common barn owls in that order. We excluded great horned owl from the broadcast because of their aggressive behavior toward other owls. We did not broadcast for cactus-ferruginous pygmy owls or northern spotted owls, two endangered species currently being monitored by the NPS.

During the count period, we used a flashlight to scan nearby vegetation for visual detections. If we detected a bird during the three-minute passive period, we recorded which portion of the passive period it was detected (1<sup>st</sup>, 2<sup>nd</sup>, and/or 3<sup>rd</sup> minute), the type of detection (aural, visual or both), and the distance to the bird. If a bird was detected during any of the active periods, we recorded when each bird was detected during four 30-second intervals and the type of detection (aural, visual or both). Individuals that we detected at more than one point along a transect were marked as “repeats.” We did not survey when winds exceeded 3 on the Beaufort scale (13-19 kph) or when precipitation was heavier than an intermittent drizzle.

### **Incidental Observations**

When we encountered a species of interest, a species in an unusual location or breeding behavior outside of formal surveys, we recorded the location, time of detection, and (if known) the sex and age class of the bird.

## **RESULTS**

Bird survey results for all species and parks appear in Table 8. We recorded 11,800 bird detections at diurnal bird points, 405 detections on nocturnal surveys, and 1,745 incidental observations across all parks. We observed a total of 190 species of birds in the five parks in 2001. SAGU E had the most species (150) while TONT and CAGR had the fewest species (47 and 55, respectively). We expected to find this pattern due to the size and topographic relief at SAGU E compared to the other parks. We found nine species at all parks, whereas 52 species were unique to only one park unit. We observed 18 species in all three strata in SAGU E and SAGU W, and 60 species that were unique to one strata or district.

The most common species varied by park, but mourning doves and Gila woodpeckers were among the most common in many parks; Gila woodpeckers at SAGU W and mourning doves at CAGR were found at all points and visits. We found ash-throated flycatchers, brown-headed cowbirds, and lesser goldfinches at all parks, and in each strata at SAGU E. Because this was the first comprehensive inventory of birds at CAGR, GICL and TUMA, most of the birds were new records for those parks. At SAGU E we found yellow-billed cuckoos and elegant trogons, two new species for the park. We did not find new species for SAGU W or TONT, but we saw black-necked stilts flying over TONT.

Table 8. Frequency of detections (%) of bird species at SODE park units, April-August 2001. Percent frequencies are derived from variable circular-plot method (VCPM) counts and nocturnal surveys, and are averaged for all points in the park unit or strata (see text for descriptions of study areas). Incidental sightings are noted with (•). Underlined numbers indicate that breeding behavior by one or more individuals (or pairs) of that species was observed in the park. For SAGU E, incidental and breeding records are noted only in the "Total" column. Nocturnal survey results apply only to owls and nightjars and VCPM results apply to all other taxa.

				Frequency of Detection by Park (%) <sup>a</sup>										
Order	Family	Scientific name	Common name	CAGR	GICL	TONT	TUMA	SAGU West	SAGU East Elevation Strata					
									Low <sup>b</sup>	Low Special <sup>c</sup>	Mid <sup>d</sup>	High <sup>e</sup>	High Special <sup>f</sup>	Total <sup>g</sup>
<b>Ciconiiformes</b>														
	Ardeidae	<i>Ardea herodias</i>	great blue heron			<u>7</u>								
	Cathartidae	<i>Mycteria americana</i>	turkey vulture		6	50	11	6	6	21	7			8
		<i>Coragyps atratus</i>	black vulture				3							
<b>Anseriformes</b>														
	Anatidae	<i>Anas platyrhynchos</i>	mallard	4	2					2				1
		<i>Dendrocygna autumnalis</i>	black-bellied whistling-duck				•							
		<i>Mergus merganser</i>	common merganser		9									
<b>Falconiformes</b>														
	Accipitridae	<i>Accipiter striatus</i>	sharp-shinned hawk		•		3			1				>1
		<i>Accipiter cooperii</i>	Cooper's hawk				9			13				<u>3</u>
		<i>Accipiter gentilis</i>	northern goshawk										8	<u>1</u>
		<i>Parabuteo unicinctus</i>	Harris's hawk					<u>7</u>						•
		<i>Asturina nitida</i>	gray hawk				20							
		<i>Buteogallus anthracinus</i>	common black-hawk		•									
		<i>Buteo albonotatus</i>	zone-tailed hawk		2					1	4			<u>1</u>
		<i>Buteo jamaicensis</i>	red-tailed hawk	2	6	8		6		7	5	1		<u>3</u>
		<i>Haliaeetus leucocephalus</i>	bald eagle			4								
		<i>Aquila chrysaetos</i>	golden eagle		2			2			4			1
	Falconidae	<i>Falco sparverius</i>	American kestrel	8	<u>4</u>	4	3	6	3	5	3			2
		<i>Falco peregrinus</i>	peregrine falcon								2		5	1
		<i>Falco mexicanus</i>	prairie falcon	2				<u>8</u>						•
<b>Galliformes</b>														
	Phasianidae	<i>Meleagris gallopavo</i>	wild turkey		4								3	>1
	Odontophoridae	<i>Cyrtonyx montezumae</i>	Montezuma quail		•						8	1		3
		<i>Callipepla squamata</i>	scaled quail								1			>1
		<i>Callipepla gambelii</i>	gambel's quail	77	2	42	37	65	39	74	30			<u>32</u>
<b>Gruiformes</b>														
	Gruidae	<i>Grus canadensis</i>	Sandhill crane	2										
<b>Charadriiformes</b>														
	Charadriidae	<i>Charadrius vociferus</i>	killdeer	2	•		•							

				Frequency of Detection by Park (%) <sup>a</sup>										
Order	Family	Scientific name	Common name	CAGR	GICL	TONT	TUMA	SAGU West	SAGU East Elevation Strata					
									Low <sup>b</sup>	Low Special <sup>c</sup>	Mid <sup>d</sup>	High <sup>e</sup>	High Special <sup>f</sup>	Total <sup>g</sup>
	Recurvirostridae	<i>Himantopus mexicanus</i>	black-necked stilt	2										
	Scolopacidae	<i>Actitis macularia</i>	spotted sandpiper		●		3							
Columbiformes														
	Columbidae	<i>Columba livia</i>	rock dove	19						1				<1
		<i>Columba fasciata</i>	band-tailed pigeon									3	5	<u>1</u>
		<i>Zenaida asiatica</i>	white-winged dove	25		13	77	<u>78</u>	69	89	75	1	3	<u>55</u>
		<i>Zenaida macroura</i>	mourning dove	<u>100</u>	22	<u>83</u>	71	<u>90</u>	86	93	43	3		<u>50</u>
		<i>Columbina inca</i>	Inca dove	2			<u>3</u>	1						
		<i>Columbina passerina</i>	common ground-dove				3			14				3
Cuculiformes														
	Cuculidae	<i>Coccyzus americanus</i>	yellow-billed cuckoo				20		1					<1
		<i>Geococcyx californianus</i>	greater roadrunner				6				3			1
Strigiformes- Nocturnal Surveys														
	Tytonidae	<i>Tyto alba</i>	barn owl	●			11							
	Strigidae	<i>Otus flammeolus</i>	flamulated owl									24		8
		<i>Otus trichopsis</i>	whiskered screech-owl									43		14
		<i>Otus kennicottii</i>	western screech-owl		8		11	33	45		42			38
		<i>Bubo virginianus</i>	great horned owl	25	8			11	16	●	●	5		<u>12</u>
		<i>Glaucidium gnoma</i>	northern pygmy-owl		●						●	●		●
		<i>Micrathene whitneyi</i>	elf owl			78		58	86		8			59
		<i>Athene cunicularia</i>	burrowing owl	33										
		<i>Strix occidentalis mexicana</i>	spotted owl											●
Caprimulgiformes- Nocturnal Surveys														
	Caprimulgidae	<i>Chordeiles acutipennis</i>	lesser nighthawk	<u>42</u>			●	22	7	●				5
		<i>Chordeiles minor</i>	common nighthawk		17									
		<i>Phalaenoptilus nuttallii</i>	common poorwill	●	8	44		39			8		●	<u>27</u>
		<i>Caprimulgus vociferus</i>	whip-poor-will									62	●	<u>20</u>
Apodiformes														
	Apodidae	<i>Aeronautes saxatalis</i>	white-throated swift		2	21		11	9	4	5	3	8	5
	Trochilidae	<i>Cynanthus latirostris</i>	broad-billed hummingbird				51			8				2
		<i>Eugenes fulgens</i>	magnificent hummingbird									3	5	1
		<i>Archilochus alexandri</i>	black-chinned hummingbird	13	2	13	<u>17</u>	1	6	25	8	1		9
		<i>Calypte anna</i>	Anna's hummingbird	<u>19</u>			●		4		6	3	15	5
	Trochilidae cont.	<i>Calypte costae</i>	Costa's hummingbird			<u>17</u>		<u>11</u>	4	8	2			3
		<i>Stellula calliope</i>	calliope hummingbird		2									
		<i>Selasphorus platycercus</i>	broad-tailed hummingbird		24						4	26	5	7
		<i>Selasphorus rufus</i>	rufous hummingbird		2				1					<1

				Frequency of Detection by Park (%) <sup>a</sup>										
Order	Family	Scientific name	Common name	CAGR	GICL	TONT	TUMA	SAGU West	SAGU East Elevation Strata					Total <sup>g</sup>
									Low <sup>b</sup>	Low Special <sup>c</sup>	Mid <sup>d</sup>	High <sup>e</sup>	High Special <sup>f</sup>	
<b>Trogoniformes</b>														
	Trogonidae	<i>Trogon elegans</i>	elegant trogon										10	1
<b>Coraciiformes</b>														
	Alcedinidae	<i>Ceryle alcyon</i>	belted kingfisher											•
		<i>Chloroceryle americana</i>	green kingfisher					•						
<b>Piciformes</b>														
	Picidae	<i>Melanerpes lewis</i>	Lewis's woodpecker					6						
		<i>Melanerpes formicivorus</i>	acorn woodpecker			30					8	8	55	9
		<i>Melanerpes uropygialis</i>	Gila woodpecker	29		63	94	100	84	81	7			36
		<i>Sphyrapicus nuchalis</i>	red-naped sapsucker			4								
		<i>Picoides scalaris</i>	ladder-backed woodpecker	2		21	31	10	20	40	24			19
		<i>Picoides villosus</i>	hairy woodpecker			4	•					6	18	3
		<i>Picoides arizonae</i>	Arizona Woodpecker								3	6	8	3
		<i>Colaptes auratus</i>	northern flicker			30	6				1	29	23	8
		<i>Colaptes chrysoides</i>	gilded flicker	15		13		32	23	8	6			8
<b>Passeriformes</b>														
	Tyrannidae	<i>Camptostoma imberbe</i>	northern beardless-tyrannulet				6		1	18				4
		<i>Contopus cooperi</i>	olive-sided flycatcher											•
		<i>Contopus pertinax</i>	greater pewee									15	25	6
		<i>Contopus sordidulus</i>	western wood-pewee	4	11					2	17	16	45	13
		<i>Empidonax traillii</i>	willow flycatcher				•							
		<i>Empidonax hammondii</i>	Hammond's flycatcher						3			1		1
		<i>Empidonax oberholseri</i>	dusky flycatcher						1					<1
		<i>Empidonax wrightii</i>	gray flycatcher			2		1	3	1				1
		<i>Empidonax difficilis</i>	Pacific-slope flycatcher				•			1				<1
		<i>Empidonax occidentalis</i>	cordilleran flycatcher			13						23	23	7
		<i>Empidonax fulvifrons</i>	buff-breasted flycatcher											•
		<i>Sayornis nigricans</i>	black phoebe			7		3		7	3			2
		<i>Sayornis saya</i>	Say's phoebe			•	17	17						•
		<i>Pyrocephalus rubinus</i>	vermillion flycatcher				37			11				2
	Tyrannidae cont.	<i>Myiarchus tuberculifer</i>	dusky-capped flycatcher			2	20				6	18	23	8
		<i>Myiarchus cinerascens</i>	ash-throated flycatcher	13	28	63	40	85	85	71	77	31	23	63
		<i>Myiarchus tyrannulus</i>	brown-crested flycatcher			29	40	17	41	54	13			23
		<i>Myiodynastes luteiventris</i>	sulphur-bellied flycatcher										10	1
		<i>Tyrannus vociferans</i>	Cassin's kingbird			9	31		1	5	7			3
		<i>Tyrannus verticalis</i>	western kingbird	10			17	1	4	2				1
	Laniidae	<i>Lanius ludovicianus</i>	loggerhead shrike	2										



Order	Family	Scientific name	Common name	Frequency of Detection by Park (%) <sup>a</sup>										Totals <sup>g</sup>	
				CAGR	GICL	TONT	TUMA	SAGU West	SAGU East Elevation Strata						
									Low <sup>b</sup>	Low Special <sup>c</sup>	Mid <sup>d</sup>	High <sup>e</sup>	High Special <sup>f</sup>		
Vireonidae	<i>Vireo vicinior</i>	gray vireo												●	
	<i>Vireo bellii</i>	Bell's Vireo				<u>92</u>	<u>46</u>		6	56				<u>13</u>	
	<i>Vireo huttoni</i>	Hutton's Vireo									15	20	25	<u>11</u>	
	<i>Vireo gilvus</i>	warbling vireo			31	4	3		1	2		3		<u>1</u>	
	<i>Vireo plumbeus</i>	plumbeous vireo			20						1	20	40	<u>8</u>	
Corvidae	<i>Cyanocitta stelleri</i>	Steller's jay			39							29	18	<u>8</u>	
	<i>Aphelocoma ultramarina</i>	Mexican jay									36	39	20	<u>20</u>	
	<i>Aphelocoma californica</i>	western scrub-jay			9		●	1	5	4	10	5		<u>6</u>	
	<i>Gymnorhinus cyanocephalus</i>	pinyon jay			2										
	<i>Corvus cryptoleucus</i>	Chihuahan raven					●								
	<i>Corvus corax</i>	common raven	8	28	21			<u>10</u>	11	17	5	19	15	13	
Alaudidae	<i>Eremophila alpestris</i>	horned lark	8												
Hirundinidae	<i>Progne subis</i>	purple martin			33			14		37	1			<u>8</u>	
	<i>Tachycineta thalassina</i>	violet-green swallow			<u>67</u>					5	4	18	28	<u>8</u>	
	<i>Stelgidopteryx serripennis</i>	northern rough-winged swallow			<u>2</u>		6								
	<i>Petrochelidon pyrrhonota</i>	cliff swallow	<u>29</u>	<u>4</u>			17	1							
	<i>Hirundo rustica</i>	barn swallow					17								
Paridae	<i>Poecile gambeli</i>	mountain chickadee			4							16	33	<u>7</u>	
	<i>Baeolophus wollweberi</i>	bridled titmouse			4		29				12	8	15	<u>6</u>	
Remizidae	<i>Auriparus flaviceps</i>	verdin	25			71	<u>46</u>	<u>88</u>	59	85	4			<u>31</u>	
Aegithalidae	<i>Psaltiriparus minimus</i>	bushtit			<u>17</u>						9	9	18	<u>6</u>	
Sittidae	<i>Sitta canadensis</i>	red-breasted nuthatch											3	<1	
	<i>Sitta carolinensis</i>	white-breasted nuthatch			15		●				1	21	53	<u>10</u>	
	<i>Sitta pygmaea</i>	pygmy nuthatch			4							10	5	<u>3</u>	
Certhiidae	<i>Certhia americana</i>	brown creeper										6	15	<u>3</u>	
Troglodytidae	<i>Campylorhynchus brunneicapillus</i>	cactus wren	8			54		<u>95</u>	88	60	31			<u>39</u>	
	<i>Salpinctes obsoletus</i>	rock wren			●	<u>54</u>		9	11	1	22	6		<u>10</u>	
	<i>Catherpes mexicanus</i>	canyon wren			<u>24</u>	88		36	18	20	46	26	5	<u>27</u>	
Troglodytidae cont.	<i>Thryomanes bewickii</i>	Bewick's wren			6	25	77		4	57	70	56	57	<u>50</u>	
	<i>Troglodytes aedon</i>	house wren			<u>31</u>	4	●				2	18	5	<u>5</u>	
Regulidae	<i>Regulus calendula</i>	ruby-crowned kinglet											3		
Sylviidae	<i>Poliophtila caerulea</i>	blue-gray gnatcatcher			7	21		1			21	19	8	<u>11</u>	
	<i>Poliophtila melanura</i>	black-tailed gnatcatcher	2			38		57	30	17				<u>10</u>	
Turdidae	<i>Sialia mexicana</i>	western bluebird			●				1		1	21	3	<u>5</u>	
	<i>Catharus guttatus</i>	hermit thrush			●							20	33	<u>7</u>	
	<i>Turdus migratorius</i>	American robin			<u>56</u>							28	5	<u>6</u>	
Mimidae	<i>Mimus polyglottos</i>	northern mockingbird	44		●		<u>9</u>	7	13	2	35			<u>13</u>	

Order	Family	Scientific name	Common name	Frequency of Detection by Park (%) <sup>a</sup>										Totals <sup>g</sup>	
				CAGR	GICL	TONT	TUMA	SAGU West	SAGU East Elevation Strata						
									Low <sup>b</sup>	Low Special <sup>c</sup>	Mid <sup>d</sup>	High <sup>e</sup>	High Special <sup>f</sup>		
		<i>Toxostoma bendirei</i>	Bendire's thrasher					1							
		<i>Toxostoma curvirostre</i>	curve-billed thrasher		2	17	<u>23</u>	<u>63</u>	49	51	4			<u>22</u>	
		<i>Toxostoma crissale</i>	Crissal thrasher				3								
Sturnidae		<i>Sturnus vulgaris</i>	European starling	<u>23</u>			<u>9</u>			4				1	
Motacillidae		<i>Anthus rubescens</i>	American pipit	2											
Bombycillidae		<i>Bombycilla cedrorum</i>	cedar waxwing							1				<1	
Ptilonotidae		<i>Phainopepla nitens</i>	phainopepla	2		4	<u>51</u>	3	5	10	18			<u>8</u>	
Peucedramidae		<i>Peucedramus taeniatus</i>	olive warbler									5	20	3	
Parulidae		<i>Vermivora celata</i>	orange-crowned warbler					1	4					1	
		<i>Vermivora virginiae</i>	Virginia's warbler		30					1	11	13	13	<u>7</u>	
		<i>Vermivora luciae</i>	Lucy's warbler	2		<u>21</u>	<u>66</u>	1	9	80				<u>19</u>	
		<i>Dendroica petechia</i>	yellow warbler	2	9	8	<u>37</u>			15				3	
		<i>Dendroica coronata</i>	yellow-rumped warbler	2	2					2	2	19	13	<u>6</u>	
		<i>Dendroica nigrescens</i>	black-throated gray warbler	●	7			1	1		27	43	40	<u>20</u>	
		<i>Dendroica townsendi</i>	Townsend's warbler		2					1		1		1	
		<i>Dendroica occidentalis</i>	hermit warbler											●	
		<i>Dendroica graciae</i>	Grace's warbler		2							20	55	<u>10</u>	
		<i>Oporornis tolmiei</i>	Macgillivray's warbler	2	2										
		<i>Geothlypis trichas</i>	common yellowthroat		●		34								
		<i>Wilsonia pusilla</i>	Wilson's warbler	4	4	4		●	4	6	2	1	3	3	
		<i>Cardellina rubrifrons</i>	red-faced warbler		19							10	15	<u>4</u>	
		<i>Myioborus pictus</i>	painted redstart		<u>28</u>							4	18	<u>3</u>	
		<i>Icteria virens</i>	yellow-breasted chat		31		<u>71</u>								
Thraupidae		<i>Piranga flava</i>	hepatic tanager		20						11	13	28	<u>8</u>	
		<i>Piranga rubra</i>	summer tanager			4	49			18				<u>4</u>	
		<i>Piranga ludoviciana</i>	western tanager	2	50		11	●	1	4	4	29	48	<u>13</u>	
Emberizidae		<i>Pipilo chlorurus</i>	green-tailed towhee	2	4		3	3	3	4	2			2	
		<i>Pipilo fuscus</i>	canyon towhee		<u>11</u>	<u>50</u>	●	49	50	27	22			<u>22</u>	
		<i>Pipilo aberti</i>	Abert's towhee			38	<u>29</u>		1	21				5	
		<i>Pipilo maculatus</i>	spotted towhee		<u>69</u>						37	69	48	<u>29</u>	
		<i>Aimophila carpalis</i>	rufous-winged sparrow				9	13	4	23	1			6	
		<i>Aimophila ruficeps</i>	rufous-crowned sparrow			8	●	6	43	2	67	20	5	<u>33</u>	
		<i>Spizella passerina</i>	chipping sparrow	4	<u>4</u>		6	1	4	4	1			2	
		<i>Spizella breweri</i>	Brewer's sparrow	6	●			13	1	6				2	
		<i>Spizella atrogularis</i>	black-chinned sparrow			4			3		28	11		<u>11</u>	
		<i>Poocetes gramineus</i>	vesper sparrow							1				<1	
		<i>Chondestes grammacus</i>	lark sparrow	2	●		●		1	1				1	

Order	Family	Scientific name	Common name	Frequency of Detection by Park (%) <sup>a</sup>										Total <sup>g</sup>
				CAGR	GICL	TONT	TUMA	SAGU West	SAGU East Elevation Strata					
									Low <sup>b</sup>	Low Special <sup>c</sup>	Mid <sup>d</sup>	High <sup>e</sup>	High Special <sup>f</sup>	
		<i>Amphispiza bilineata</i>	black-throated sparrow			25	●	<u>57</u>	80	32	9			26
		<i>Calamospiza melanocorys</i>	lark bunting	4										
		<i>Melospiza melodia</i>	song sparrow				<u>54</u>			1				<1
		<i>Zonotrichia leucophrys</i>	white-crowned sparrow				3	2	6	1	1			2
		<i>Junco hyemalis</i>	dark-eyed junco		6									
		<i>Junco phaeonotus</i>	yellow-eyed junco									39	45	<u>12</u>
Cardinalidae		<i>Cardinalis cardinalis</i>	northern cardinal			<u>71</u>	<u>54</u>	8	34	67	1			<u>21</u>
		<i>Cardinalis sinuatus</i>	pyrrhuloxia					<u>47</u>	9	4				3
		<i>Pheucticus melanocephalus</i>	black-headed grosbeak		56		3	1	1	6	21	40	45	20
		<i>Guiraca caerulea</i>	blue grosbeak		<u>20</u>		<u>9</u>		3	12				<u>3</u>
		<i>Passerina amoena</i>	lazuli bunting		●		9	1	1	11				3
		<i>Passerina cyanea</i>	indigo bunting		●	8	●			1				<1
		<i>Passerina ciris</i>	painter bunting				●							
		<i>Passerina versicolor</i>	varied bunting				3	3	3	18				4
	Icteridae		<i>Agelaius phoeniceus</i>	red-winged blackbird	25			●						
		<i>Euphagus cyanocephalus</i>	Brewer's blackbird		6		●							
		<i>Quiscalus mexicanus</i>	great-tailed grackle	67			31	2						
		<i>Molothrus aeneus</i>	bronzed cowbird				3				1			1
		<i>Molothrus ater</i>	brown-headed cowbird	<u>4</u>	13	17	<u>77</u>	50	23	43	23	8	13	<u>23</u>
		<i>Icterus cucullatus</i>	hooded oriole			<u>33</u>	6		1	1				1
		<i>Icterus parisorum</i>	Scott's oriole			4		11	26	5	44	3		<u>19</u>
		<i>Icterus bullockii</i>	Bullock's oriole	2	●		<u>9</u>	5	6	6				3
Fringillidae			<i>Carpodacus mexicanus</i>	house finch	75	4	33	43	49	53	51	28		
		<i>Carduelis pinus</i>	pine siskin									1	3	1
Fringillidae cont.		<i>Carduelis psaltria</i>	lesser goldfinch	4	13	8	60	8	14	48	4	3	8	15
Passeridae		<i>Passer domesticus</i>	house sparrow	54			17							●
Species richness				55	93	47	89	63	68	81	77	67	60	150
Number of breeding records				7	15	8	19	12	NA	NA	NA	NA	NA	62

<sup>a</sup> The number of individuals of each species that we recorded at each point and visit did not affect its frequency.

<sup>b</sup> Low elevation (<4,000 feet) random for diurnal surveys, and Loop Road and Rincon Creek transects for nocturnal surveys.

<sup>c</sup> Low elevation (diurnal) riparian transects: upper and lower Rincon Creek, Box Canyon and Loma Verde Creek.

<sup>d</sup> Mid elevation (4,000-6,000 feet) random transects for diurnal surveys and Cowhead Saddle for nocturnal surveys.

<sup>e</sup> High elevation (>6,000 feet) random transects for diurnal surveys, and Happy Valley Saddle and Manning Camp for nocturnal surveys.

<sup>f</sup> High elevation (diurnal) special area transects: Rincon Peak and Happy Valley Saddle.

<sup>g</sup> All points in all strata combined.

## FISHES

The Santa Cruz River (SCR) adjacent to the Mission unit of Tumacacori is the only area in the network with fishes that has not had surveys in recent years. We surveyed on two occasions, once each in the spring and fall in 2001. We chose to survey during times when the water temperature was cooler and therefore less stressful for the fish.

## METHODS

### Survey Methods

In accordance with our permits, we captured fishes using a backpack electrofisher (Smith-Root 12-B POW) with pulsed DC, a pulse width of 60 Hz, frequency of 6 ms, and voltage of 300 V. At Cospar Slough (CS), we also used long-handled dip nets with 4 mm mesh (Dauble and Gray 1980). We identified captured fishes to the lowest practical taxon, classified them as juvenile or adult, and sexed them, when possible. We returned all fishes to the general area from which they were captured. We had a field crew of three conduct all surveys.

### Survey Areas

#### Santa Cruz River

On April 3 and November 11, we surveyed along the main channel of the SCR. We surveyed from 30 m downstream (north) from the confluence of the SCR and CS to about 25 m upstream (south) of Santa Gertrudis Lane. We chose this stretch of river because of the excellent fish habitat and because most of the area would be included in a future land acquisition (see park description on page 6). We randomly chose one side of the river from which to begin surveying, then surveyed from the stream margin to the midline, concentrating on likely areas (e.g., stream margins and in-stream obstructions). We surveyed about 100 m of stream, skipped 150 m of stream, then surveyed another 100 m of stream, alternating sides of the river. We repeated this pattern until finished.

#### Cospar Slough

On April 4 and November 12, we surveyed along CS from its confluence with the SCR and proceeded upstream to the headwaters of CS. We surveyed about 50 m of stream, skipped 50 m, then surveyed another 50 m of stream, repeating this pattern until finished. We used electrofishing for the first 50 to 100 m, and dip-nets for the rest of the slough. The latter was chosen for its effectiveness at sampling and at lessening the potential of injury to the endangered Gila topminnow. On November 12, due to the high number of fishes captured in the first sampling run, we estimated abundance of longfin dace, Gila topminnow, and mosquitofish for the last 25 m of the first sampling run and for the entire second sampling run.

## RESULTS

We found seven species (and one hybrid) of fishes during the four days of sampling along the SCR and CS adjacent to TUMA (Table 9). The most abundant species in the SCR was the Gila topminnow in April and longfin dace in November. In CS, the abundant species were the longfin dace during both sample periods and the non-native mosquitofish in November. Numbers of

individuals for the most dominant species varied greatly between sampling periods. For example, numbers of longfin dace in the SCR increased from 11 to 434 between April and November. On November 12 in CS, longfin dace numbered in the hundreds for the last 25 m of the first sampling run and in the tens to hundreds for the second sampling run. Gila topminnow and mosquitofish numbered in the hundreds to thousands for both the last 25 m of the first sampling run and the second sampling run, with mosquitofish probably more abundant.

Species richness was higher in CS (7 species and 1 hybrid) than in the SCR (5 species)(Table 9). Non-native green sunfish was the only species found in the SCR that was not found in CS. Non-native species made up 3 of the 5 species in the SCR and 4 of 7 species (not including the hybrid) in CS. There was a temporal difference in species richness in the SCR, with the highest diversity in April. There was little difference in richness between sampling events for the CS, though there was considerable species turnover between sampling events (Table 9).

During the April survey, we observed that some desert and Sonora suckers had coloration and tubercles, respectively. These characteristics were probably associated with spawning activity.

**Table 9. Results of fish surveys adjacent to TUMA, 2001. Relative abundance (RA) is expressed as a percent of the total catch (TC) for all species on that date.**

Order	Family	Scientific Name	Common Name	Cospar Slough				Santa Cruz River			
				4 April		12 Nov. <sup>a</sup>		3 April		11 Nov.	
				TC	RA	TC	RA	TC	RA	TC	RA
<b>Cypriniformes</b>											
	Cyprinidae	<i>Agosia chrysogaster</i>	longfin dace	36	58	185	33	11	31	434	86
<b>Cypriniformes</b>											
	Catostomidae	<i>Catostomus insignis</i>	Sonora sucker	3	5	6	1				
		<i>Catostomus clarkii</i>	desert sucker	4	6	1	<1				
<b>Cyprinodontiformes</b>											
	Poeciliidae	<i>Poeciliopsis occidentalis</i>	Gila topminnow	6	10	43	8	17	50	11	2
		<i>Gambusia affinis</i> <sup>b</sup>	western mosquitofish	10	16	319	57	2	6	58	12
<b>Perciformes</b>											
	Centrarchidae	<i>Micropterus salmoides</i> <sup>b</sup>	largemouth bass			2	<1	1	3		
		<i>Lepomis macrochirus</i> <sup>b</sup>	bluegill	2	3	2	<1				
		<i>Lepomis cyanellus</i> <sup>b</sup>	green sunfish					4	11		
		<i>L. macrochirus</i> x <i>L. cyanellus</i> <sup>b</sup>	Lepomid hybrid	1	2						
<b>Species richness</b>				6		7		5		3	

<sup>a</sup> Does not include visual estimates of abundance for longfin dace, Gila topminnow and mosquitofish (see text).

<sup>b</sup> Non-native species.

## TERRESTRIAL MAMMALS

We surveyed for mammals using a variety of techniques depending on taxonomic targets: trapping, infrared photography, predator calls, and incidental observation and sign.

### METHODS – SMALL MAMMALS

We trapped rodents and desert shrews (*Insectivora*) at GICL, SAGU, TONT, and TUMA. We used three study designs at FPT plots, special-area plots or grids, and pitfall traps. At SAGU, most of our effort was at FPTs, whereas at TONT and GICL, most of our effort was at special area grids. We trapped at TUMA in 2000 and 2001 and all other parks in 2001.

#### General Trapping Methods

With all study designs (unless otherwise noted) we used Sherman live traps placed in grids or lines (White et al. 1983). We opened traps in the evening and then closed each trap after checking it the following morning to prevent mortality resulting from heat exposure. When setting traps, we placed one tablespoon of bait (16 parts dried oatmeal, four parts black oil sunflower seed [except at TUMA], and one part peanut butter) in each trap.

We marked each captured animal with a permanent marker to facilitate recognition (in case it was recaptured) and recorded species, sex, age, reproductive condition, weight, and measurements for right-hind foot, tail, ear, and head and body. We identified juveniles to genus only, and if we could not identify an adult, we euthanized it with isoflourane and subsequently prepared the specimen for future identification.

#### Focal-point Transects

Focal point transects at SAGU were divided into 20 potential 50 x 50 m trapping plots, each centered on the transect midline (Fig. 7). From mid-April through mid-June, 2001, we used three pairs of plots (each pair was 50 x 100 m) to accommodate a 3 x 7 trap array (Figs. 7 and 8). We placed the first line of seven traps 16.5 m apart along the transect midline. We set the other two lines of traps 25 m on each side of the midline. If it was not possible to survey the randomly assigned grids because of safety considerations for field workers, we trapped at the next acceptable pair of plots toward the transect midpoint. In mid-June we changed our focal-point grid design to three 50 x 50 m plots with 25 traps (5 x 5) each, with uniform 12.5-m spacing among traps. We used this array because it gave us more concentrated trap coverage.

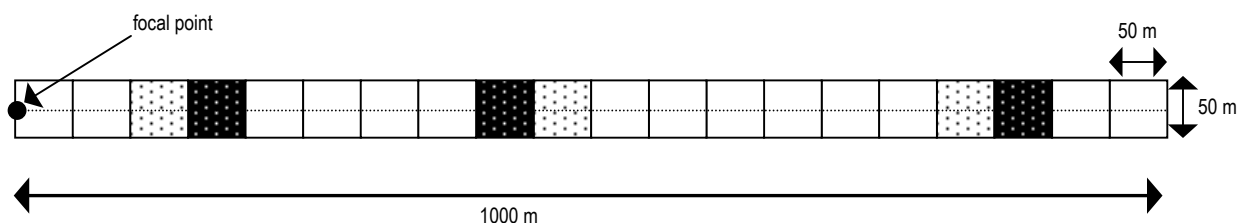


Figure 7. Example of a small mammal grid layout along FPTs at SAGU, 2001. From mid-April through mid-June, we trapped small mammals at all three sets of adjacent pairs of 50 x 50 m plots (light and dark dotted boxes) and during the remainder of the season we trapped at three of the 50 x 50 m plots, one from each pair of adjacent plots (dark dotted boxes).

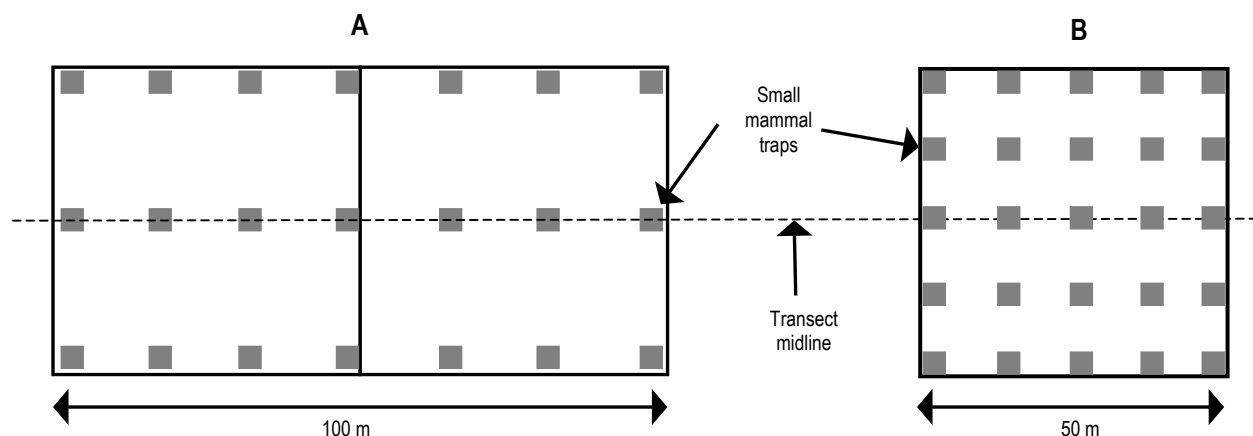


Figure 8. Detailed layout of small mammal trapping grids at FPTs in SAGU (A and B) and GICL (B). We used 3 x 7 trap grids in 50 x 100 m plots (A) from mid-April through mid-June and 5 x 5 trap grids in 50 x 50 m plots (B) from mid-June through October.

At most FPTs, we trapped for three nights on two occasions between April and October. We did not sample at nine of the FPTs surveyed for the other taxa in order to concentrate on better temporal coverage of the remaining ones. We had low trap success in the early season, thus we chose to drop an additional four FPTs for the second trapping season to focus more of our efforts in special areas.

We marked the southwest corner of each trapping plot with a rebar stake. We recorded the UTM coordinates of the plot corners using a Tremble GPS unit.

#### **Random Plots: Tumacacori National Historical Park**

We began trapping small mammals at all three units of TUMA in the fall of 2000. We trapped at 31 sites; 17 at Tumacacori, nine at Calabasas, and five at Guevavi. With the exception of the first round of trapping at Calabasas, the location of most trapping grids was random. At the Mission site, we randomly located grids within an area that encompassed lands south from Santa Gertrudis Lane to approximately 1 km north of the Mission, east to Cospar Slough and west to the East Frontage Road. We trapped over three or four 3-day periods (herein referred to as visits) per trapping season; generally one visit to Calabasas and Guevavi and the other two visits at, or adjacent to, the Mission. At Calabasas and Guevavi we arranged traps into 5 x 5 grids within 40 x 40 m plots with 10 m spacing among traps. At the Mission site we placed traps into 10 x 5 grids within 90 x 40 m plots with 10 m spacing among traps. We trapped for three nights at each grid and marked animals with different colors for each night. We recorded the same information as at the other parks except the way we recorded reproductive condition: males - scrotal or nonreproducing; females - nonreproducing, open pubis, closed pubis, enlarged nipples, small or non-present nipples, lactating, postlactating, or nonlactating.

#### **Special-areas Trapping Grids**

##### Gila Cliff Dwellings National Monument

We trapped small mammals at six randomly placed plots and three special-area plots at GICL from May 25 to 30 and from August 31 to September 5, 2001. For all but one plot we used a 5 x 5 trap array in 50 x 50 m plots and in Cliff Dweller Canyon, we used a 12 x 2 trap array in approximately 120 x 20 m plots. We used the same data recording methods as at FPTs.

### Saguaro National Park

We preferentially selected 30 sites (19 in SAGU E and 11 in SAGU W) for trapping because special areas (such as riparian corridors or sites with dense groundcover) were expected to have high diversity and abundance of small mammals. We recorded UTM coordinates for each special area, but did not mark them with rebar. We set up special area plots in SAGU W near Rudasill, Picture Rocks and Kinney Roads; on bajadas west of the Tucson Mountains; below Wasson Peak; and south of Apache Peak. At SAGU E, we set up mid-elevation special area plots at Wildhorse Corral and Grass Shack, and high-elevation plots at Spud Rock Summit, Spud Rock Spring/Cabin, Mica Mountain, Italian Spring and Manning Camp.

### Tonto National Monument

We trapped for two nights in October, 2001 at TONT along the spring-fed riparian area below the upper ruins. We placed two rows of traps on either side of the creek with approximately 15-m spacing between traps in each row. We also placed two 10 x 2 trap grids, with 12.5 m spacing among traps, in two upland sites. We used the same data recording methods as at FPTs.

### **Pitfall trapping**

It is possible that *Sorex merriami*, *S. vagrans*, and *S. arizonae* (shrews) occur in the Rincon Mountains, because they have been found in other mountain ranges in southern Arizona. Therefore, to survey for *Sorex*, we placed pitfall traps (3-quart buckets [19 cm tall x 14 cm wide]) in three areas on moist, north-facing slopes of the Rincon Mountains. We placed traps adjacent to a natural feature such as a fallen log or rock. We checked traps every 10 days to two weeks.

### **Voucher Specimens**

Because of subtle variations in pelage color patterns and overlapping external measurements among species, we sometimes euthanized individuals to verify identification and preserve as museum specimens. All specimens were prepared according to standardized techniques and placed in the UA mammal collection.

## **METHODS – MEDIUM AND LARGE MAMMALS**

We used four techniques to identify and document medium and large mammals: infrared-triggered cameras, simulated prey vocalizations, collection of sign and incidental sightings.

### **Infrared-triggered Cameras**

We used five infrared-triggered cameras at SAGU W and one each at GICL and TUMA. Don Swann has been using cameras at SAGU E since 2000, thereby making it unnecessary for our program use cameras there. We placed all but one camera in or near a wash and the other camera near a water source in SAGU W. We baited sites with commercial scent lures or canned cat food. We checked cameras approximately every two weeks to change film and batteries and ensure their proper function. On the first exposure of every new roll of film, we photographed a placard documenting the date and camera location.

### **Predator Calls**

We experimented using predator calls to detect medium and large carnivores. Using one of three different calls, we broadcasted the vocalizations of prey animals in distress to attract predators. Although



we had some initial success, the technique proved too difficult to execute properly in typical field conditions.

### **Incidental Observations and Sign**

All field crews recorded UTM coordinates of sightings of mammals. We also collected or recorded incidental information such as tracks or scat, and when appropriate, we took photo vouchers of these sign. In the beginning of the season we used transects in an attempt to standardize recording of sign observation, but we did not collect enough data to warrant continuation of this practice.

### **Voucher Specimens**

In addition to the small mammals collected during trapping efforts, we also collected carcasses (due to natural mortality or road kill) and bones, including skulls, to serve as voucher specimens.

## **RESULTS – SMALL MAMMALS**

We found 25 species of small mammals in 8,360 trap nights in the four parks during the 2000 and 2001 field seasons (Table 10). The sites with the highest and lowest species diversity were Calabasas at TUMA and GICL, respectively, and the areas with the highest and lowest diversity *per trap night* were TONT and high-elevation random areas at SAGU E, respectively. The number of trap nights at each park and site varied from 146 at TONT to 1,715 at TUMA. The areas with the most and least trap success were TONT and GICL, respectively.

We found white-throated woodrat and brush mouse in all parks (Table 10). We found 7 species in only one park, site or stratum.

Table 10. Frequency (%) of captures of small mammal species, by park unit, from trapping efforts in 2000 and 2001. Frequencies are derived from relative abundances, which were scaled to reflect adjusted trapping effort<sup>a</sup> and did not include recaptures. Except where noted, all random plots at SAGU E and W were trapped in spring and summer, special areas in summer only. Incidental sightings (●) for SAGU E are recorded in the "Random Pooled" column only.

			Frequency of Captures by Park Unit and Site														
			TUMA		TON T	GICL		SAGU W		SAGU E					Elevation Stratum		
Order	Family	Latin name	Common name	Calabasas	Guevavi	Mission	Riparian	Random	Special	Random	Special <sup>c</sup>	Low random	Mid random	Mid special <sup>d</sup>	High random	High special <sup>e</sup>	Random pooled <sup>f</sup>
<b>Insectivora</b>																	
	Soricidae	<i>Notiosorex crawfordi</i>	desert shrew	1		1		5								5 <sup>g</sup>	
<b>Rodentia</b>																	
	Sciuridae	<i>Eutamias dorsalis</i>	cliff chipmunk				2	5						3	19	12	6
		<i>Ammospermophilus harrisi</i>	Harris' antelope ground squirrel							1							●
		<i>Spermophilus variegatus</i>	rock squirrel													8	
		<i>Sciurus aberti</i>	Abert's squirrel													8	
		<i>Sciurus arizonensis</i>	Arizona gray squirrel														●
	Geomyidae	<i>Thomomys bottae</i>	Botta's pocket gopher													1 <sup>g</sup>	
	Heteromyidae	<i>Perognathus amplus</i>	Arizona pocket mouse							18	4						
		<i>Chaetodipus intermedius</i>	rock pocket mouse							16	37	56	45				33
		<i>Chaetodipus penicillatus</i>	desert pocket mouse	38	50	17				27	36						
		<i>Chaetodipus baileyi</i>	Bailey's pocket mouse	1	1		37			14	11	3	2				2
		<i>Dipodomys merriami</i>	Merriam's kangaroo rat							15	9						
	Muridae	<i>Reithrodontomys megalotis</i>	Western harvest mouse			1		5	24					6		3	
		<i>Reithrodontomys fulvescens</i>	fulvous harvest mouse	4	11	1											
		<i>Peromyscus eremicus</i>	cactus mouse	12	9	29	56			2		12	12	10		2	8
		<i>Peromyscus maniculatus</i>	deer mouse	3		5						2					<1
		<i>Peromyscus leucopus</i>	white-footed mouse	1		6											
		<i>Peromyscus boylii</i>	brush mouse				1	66	76		2	2	18	67	62	46	28
		<i>Peromyscus truei</i>	Pinón mouse					5									
		<i>Baiomys taylori</i>	pygmy mouse		1												
		<i>Onychomys leucogaster</i>	northern grasshopper mouse		1												
		<i>Onychomys torridus</i>	southern grasshopper mouse	12	9	1											
		<i>Sigmodon arizonae</i>	Arizona cotton rat	13		13								1			<1
		<i>Sigmodon ochrognathus</i>	yellow-nosed cotton rat	4										1		3	<1
		<i>Neotoma albigula</i>	white-throated woodrat	9	17	5	4	10		7		25	20	14	3	15	16
		<i>Neotoma mexicana</i>	Mexican woodrat					5					2		16	4	6
		<i>Mus musculus</i>	house mouse	1		21											

				Frequency of Captures by Park Unit and Site													
				TUMA			TON T	GICL		SAGU W		SAGU E			Elevation Stratum		
Order	Family	Latin name	Common name	Calabasas	Guevavi	Mission	Riparian	Random	Special	Random	Special <sup>c</sup>	Low random	Mid random	Mid special <sup>d</sup>	High random	High special <sup>e</sup>	Random pooled <sup>f</sup>
Species richness				12	8	11	5	7	2	8	6	6	8	5	4	11	NA
Total adjusted trap night effort				523	348	1715	146	338	240	910	522	722	1178	291	906	521	NA
Total relative abundance				0.28	0.24	0.16	0.63	0.07	0.07	0.26	0.14	0.10	0.18	0.11	0.13	0.39	NA

<sup>a</sup> Adjusted trap effort = (total # of trap nights x total # of traps) - (total # of sprung traps x 0.5) (Beauvais and Buskirk 1999). Spacing and number (10-60) of traps varied among trapping grids.

<sup>b</sup> Low elevation <4,000 feet; Mid elevation 4,000-6,000 feet; High elevation >6,000 feet.

<sup>c</sup> SAGU W special areas: Rudasill, Picture Rock and Kinney Roads, bajadas west of Tucson Mountains, below Wasson Peak, Canyon and south of Apache Peak.

<sup>d</sup> SAGU E mid-elevation special areas: Wildhorse Corral and Grass Shack.

<sup>e</sup> SAGU E high-elevation special areas: Spud Rock Summit, Spud Rock Spring/Cabin, Mica Mountain, Italian Spring, Manning Camp.

<sup>f</sup> All random areas combined.

<sup>g</sup> Found in pitfall traps. Not included in "trap-night effort" or "total relative abundance" summaries.

**RESULTS – MEDIUM AND LARGE MAMMALS**

We found 23 species of medium and large mammals at all parks surveyed (Table 11). We obtained 177 photographs of identifiable animals at camera sites at GICL, SAGU W and TUMA. Based on these results, the most common species at GICL was the hog-nosed skunk, at SAGU W the gray fox, and at TUMA the opossum.

**Table 11. Relative frequency (%) of occurrence of medium and large mammals based on results from infrared-triggered cameras at GICL, SAGU W, and TUMA, 2001. Incidental observations (●) are from track counts, observation or sign at those park units and SAGU E.**

Order	Family	Scientific Name	Common Name	GICL	SAGU West	SAGU East	TUMA
<b>Didelphimorphia</b>							
	Didelphidae	<i>Didelphis marsupialis</i>	opossum				63
<b>Carnivora</b>							
	Canidae	<i>Canis latrans</i>	coyote	●	6.5	●	
		<i>Canis familiaris</i>	feral dog		●		●
		<i>Urocyon cinereoargenteus</i>	gray fox	17.6	65.6	●	
	Ursidae	<i>Ursus americanus</i>	black bear	11.8		●	
	Felidae	<i>Felis concolor</i>	mountain lion	●	●	●	
		<i>Felis silvestris</i>	house cat				2.6
		<i>Lynx rufus</i>	bobcat			●	
	Mephitidae	<i>Mephitis macroura</i>	hooded skunk		6.5		7.9
		<i>Mephitis mephitis</i>	striped skunk	11.8	0.8	●	5.3
		<i>Conepatus mesoleucus</i>	hog-nosed skunk	52.9	0.8		
		<i>Spilogale gracilis</i>	western spotted skunk		1.6		10.5
	Mustelidae	<i>Taxidea taxus</i>	badger		1.6		
		<i>Mustela vison</i>	long-tailed weasel	● <sup>a</sup>			
	Procyonidae	<i>Procyon lotor</i>	raccoon	●			
		<i>Nasua narica</i>	coati			●	
<b>Rodentia</b>							
	Castoridae	<i>Castor canadensis</i>	beaver	●			
<b>Lagomorpha</b>							
	Leporidae	<i>Sylvilagus</i> spp. <sup>b</sup>	cottontail species	●	●	●	5.3
		<i>Lepus californicus</i>	black-tailed jackrabbit		0.8	●	● <sup>c</sup>
<b>Artiodactyla</b>							
	Tayassuidae	<i>Pecari tajacu</i>	collared peccary	●	14.8	●	5.3
	Cervidae	<i>Odocoileus hemionus</i>	mule deer	●	●	●	
		<i>Odocoileus virginianus</i>	whitetail deer	●		●	
		<i>Cervus elaphus</i>	elk	●			
<b>Percent of other animals at camera sites</b>				<b>6.0</b>	<b>0.8</b>	<b>NA</b>	<b>0</b>
<b>Total number of pictures</b>				<b>17</b>	<b>122</b>	<b>NA</b>	<b>38</b>
<b>Species Richness</b>				<b>14</b>	<b>13</b>	<b>12</b>	<b>9</b>

<sup>a</sup> Identification not certain - obtained from single track

<sup>b</sup> *Sylvilagus audubonii* (desert cottontail) or *S. floridanus* (eastern cottontail)

<sup>c</sup> Seen 50 m outside of Guevavi

## BATS

### METHODS

We concentrated our survey effort in areas that were most likely to have bats, mostly mesic riparian areas and roost sites. Therefore, we did not specifically look for bats near FPTs.

### Roosts

We visited three roosts known or likely to have bats (Table 12). Once at a roost, we observed bats with the aid of infrared-filtered light and night-vision equipment or red-filtered light. When bats were present, we worked quickly to identify them to species, but if there were no bats we used bright light, then searched for and collected skeletal material.

**Table 12. Location and description of bat observation sites at SODE park units, 2001.**

Park Unit	Location	Abbreviation	Roost (R) or Net (N) site	Number of visits
GICL	West Fork Gila River	WF	N	2
	Cliff Dweller Canyon	CD	N	5
SAGU W	Gould Mine	GM	R	2
	Javelina Wash Tank	JW	N	1
	Dobe Wash Tank	DW	N	1
SAGU E	Wildhorse Canyon	WC	N	3
	Box Canyon Crevice	BC	R	1
	Chimineia Creek	CC	N	2
	Lower Rincon Creek	LR	N	3
	Manning Camp Pond	MC	N	5
	Devil's Bathtub	DB	N	1
TONT	Cave Canyon Springs	CCS	N	3
TUMA	Mission	MI	R	1

### Mist Netting

Insectivorous bats congregate at water sites in the desert. Therefore we set mist nets over 10 water sites (Table 12). We used three net sizes (5-meter, 9-meter, or 12-meter) depending on the site. We set nets singly or stacked depending on conditions. We set all nets directly over water.

For each bat captured, we recorded time of capture, species and sex. When appropriate, we recorded relative age, reproductive condition, forearm length, mass, body condition, toothwear, parasites and other measurements. We determined whether individuals were adult, subadult (by closure of epiphyses), or juvenile (by appearance). We determined age by an approximation of tooth wear. For females, we recorded reproductive condition as pregnant (palpation for fetal bones), currently lactating (mammary gland with milk), previous evidence of lactation (misshapen or scarred nipples), or nulliparity (non-use of nipples). We determined reproductive condition for males by degree of swelling of testes or the presence of black epididymides. We recorded genera of parasites when known. We marked all captured bats with a temporary, non-lethal marker to prevent counting the same individual more than once in the same evening. We took photographs of most species.

We used sonar detectors (Anabat and/or QMC Mini) at all sites to aid in determining bat presence/absence and relative activity as compared to the visual or mist-net results. However, we did not attempt to use these instruments to identify bats to species, despite the increasing use of them for this purpose. We listened passively for the call of pallid bats, the only species of bat in southern Arizona and New Mexico that can be definitively identified by its directive call. We also listened for the non-specific audible calls of free-tailed bats.

### **Voucher Specimens and Photographs**

When appropriate, we took voucher specimens. We euthanized five bats (on R. Sidner's USFWS permit) using Halothane or Isoflurane-soaked cotton balls in glass jars. We prepared the specimens as skin and skull vouchers and deposited them in the UA mammal collection. We often took photo vouchers and collected bones from caves.

### **RESULTS**

We found a combined total of 16 or 17 species of bats at all sites at GICL, SAGU, TONT and TUMA during 2001 (Table 13). Manning Camp Pond in SAGU E had the highest species richness of any site with 8 or 9 species of bats observed (there may be one or both species of *Myotis californicus* and/or *M. ciliolabrum*; we are awaiting identification). The intermittent stream at SAGU E's Lower Rincon Creek, and the confluence of Cliff Dweller Canyon and West Fork of the Gila River at GICL had six species each.

The cave bat was the most abundant species of bat recorded; a large colony was observed exiting a roost in SAGU E. The most abundant species counted at netting sites were the big brown at Manning Camp Pond (35 individuals over five nights), silver-haired at GICL (16 individuals over three nights), and Brazilian free-tailed at Lower Rincon Creek (10 individuals over two nights) (Table 13).

The pocketed free-tailed bat was a new record for SAGU. The southwestern and little brown myotis, and Brazilian free-tailed were new records for GICL. All other species had been recorded in one or more previous inventories.

**Table 13. Number of bats caught at netting sites and observed at roost sites in SODE park units, 2001. Observations are indicated by numbers of live animals or skeletal specimens (SS). See Table 9 for site descriptions.**

			Park Unit and Site																	
Family	Scientific name	Common Name	SAGU W			SAGU E						GICL		TUMA	TONT					
			GM	JW	DW	WH	BC	CC	LR	MC	DB	CD	WF	MI	CCS					
Phyllostomidae			1 (SS)																	
	<i>Macrotus californicus</i>	California leaf-nosed bat																		
	<i>Leptonycteris curasoae</i>	lesser long-nosed bat				6														
Vespertilionidae			1 (SS)	1	7							1	7							
	<i>Myotis auriculus</i>	southwestern bat				1 1														
	<i>Myotis californicus</i> and/or <i>ciliolabrum</i>	California and/or western small-footed bat <sup>a</sup>				2 2 1														
	<i>Myotis lucifugus</i>	little brown bat				1														
	<i>Myotis thysanodes</i>	fringed bat				2														
	<i>Myotis velifer</i>	cave bat				500+ 1														
	<i>Myotis volans</i>	long-legged bat				2														
	<i>Lasionycteris noctivagans</i>	silver-haired bat				1 2														
	<i>Pipistrellus hesperus</i>	western pipistrelle bat				1 2														
	<i>Eptesicus fuscus</i>	big brown bat				4 6 35 1														
	<i>Lasiurus cinereus</i>	hoary bat				1 3														
	<i>Plecotus townsendii</i>	Tonwsend's big-eared bat																		
	<i>Antrozous pallidus</i>	pallid bat																		
Molossidae																				
	<i>Tadarida brasiliensis</i>	Brazilian free-tailed bat							1 10 3											
	<i>Nyctinomops femorosaccus</i>	pocketed free-tailed bat							1											
Species richness per site			2	2	2	1	2	2-3	6	8-9 <sup>a</sup>	3-4 <sup>a</sup>	6	3	1	3					
Species richness per park					3						12	6	1	3						

<sup>a</sup> May be one or both species of *Myotis* (*M. californicus* and/or *M. ciliolabrum*). At the time of writing, we were waiting for specimen identification.

## **DATABASE EFFORTS**

### **Overview**

Existing information on vertebrates and vascular plants in SODE parks is stored in many locations, including park and regional files and natural history museums. From these sources we gathered data for GIS themes, voucher specimens and photographs, and observation records. Data were either directly entered into NPS databases or sent to the Natural Resource Information Division of the I&M Program in Fort Collins, Colorado. The quantity and quality of existing inventory information varied greatly among parks and taxa. For example, Organ Pipe National Monument had very detailed records for all taxonomic groups, while no information was available for most taxa at GICL and TUMA. Currently, we are updating our databases and are working with database managers at the regional level of the NPS to complete our goal of compiling all existing information on vascular plants and vertebrates that occur in network parks. We anticipate that this work will be ongoing throughout the duration of the project.

### **Access Database**

We created Microsoft Access databases (for all taxa) for entry, retrieval, and analysis of data from the entire inventory effort. This database will revert to the monitoring program at the completion of the project and be available to park personnel.

### **NPSpecies**

NPSpecies is the National Park Service's database program for updating and maintaining information about the occurrence, abundance and status of species in all national park units. NPSpecies has been an integral component of our efforts for compiling information on plants and animals in SODE parks. At the time of this writing, we have added over 13,000 records to the NPSpecies database using species lists from published articles, reports, collections, voucher specimens, natural history collections, and ANCS+ databases from each park.



## PROJECT COMPLETION SCHEDULE

We will use the following schedule as a guide for completing inventories and entering, analyzing, and reporting data. However, the timing of surveys may change due to personnel availability, weather, and/or budgetary restrictions.

### **March-April 2002**

- Review first field season, and refine study plans
- Distribute 2000/2001 Annual Report
- Develop 2002 field schedule and begin hiring

### **April-October 2002**

- Field work
  - Birds: CAGR, GICL, SAGU, TONT, TUMA
  - Herps: CAGR, GICL, SAGU, TONT, TUMA
  - Mammals: CAGR, GICL, SAGU, TONT, TUMA
  - Fish: TUMA
  - Plants: CAGR, GICL, SAGU

### **October 2002-April 2003**

- Compile, enter and analyze data on all new inventories
- Finish data analyses and report writing for completed inventories
- Distribute 2002 Annual Report
- Begin work on Final Reports to parks with complete inventories
- Develop 2003 field schedule

### **April-October 2003**

- Field work
  - Birds: CORO, CHIR, FOBO, TUZI
  - Herps: CHIR, TUZI
  - Mammals: CHIR, FOBO, TUZI
  - Plants: CORO, CHIR, FOBO, TUZI

### **October 2003-March 2004**

- Compile, enter and analyze data on all new inventories
- Distribute 2003 Annual Report
- Develop 2004 field schedule

### **March-October 2004**

- Field work
  - Birds: CORO, CHIR, FOBO, TUZI
  - Herps: CHIR, TUZI
  - Mammals: CHIR, FOBO, TUZI
  - Plants: CORO, CHIR, FOBO, TUZI

**October 2004-March 2005**

- Compile, enter and analyze data on all new inventories
- Complete Final Reports to parks with complete inventories
- Final Report due March 31, 2005

**PRODUCTS FROM THE INVENTORY PROGRAM**

In addition to annual reports, which are brief descriptions of the study methods and results, we will also provide each park with a customized Final Report. These reports will contain more detail than annual reports and will include reviews of past inventories, detailed maps of study areas and distribution of species of interest, more detailed analysis of results, and reviews of the efficacy of our inventory effort. We would like input from park personnel on other needs that they have for the data generated from this program.

Finally, because our approach to inventories is unique in the southwest, and perhaps the country, we will submit our findings and methods for publication in peer-reviewed scientific journals.

## LITERATURE CITED

- Arizona and New Mexico Climate Reports. 2002. Site updated by Western Regional Climate Center, National Oceanic and Atmospheric Administration. <http://www.wrcc.dri.edu/summary/climsmaz.html>. (March 1, 2002).
- Beauvais, G. P., and S. W. Buskirk. 1999. Modifying estimates of sampling effort to account for sprung traps. *Wildlife Society Bulletin* 27:39-43.
- Bibby, C. J., N. D. Burgess, and D.A Hill. 1992. *Bird Census Techniques*. Academic Press, London, England.
- Bonham, C. D. 1989. *Measurements for terrestrial vegetation*. John Wiley and Sons Inc., New York, NY.
- Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. *Distance sampling. Estimating abundance of biological populations*. Chapman and Hall, New York, NY.
- Cox, M. K., and W. L. Franklin. 1989. Terrestrial vertebrates of Scott's Bluff National Monument, Nebraska. *Great Basin Naturalist* 49:597-613.
- Crump, M. L., and N. J. Scott, Jr. 1994. Visual encounter surveys. Pages 84-92 *in* Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Haye, and M. S. Foster, eds. *Measuring and monitoring biological diversity: standard methods for amphibians*. Smithsonian, Washington, DC.
- Davis, K., and W. L. Halvorson. 2000. A study plan to inventory vascular plants and vertebrates: Sonoran Desert Network, National Park Service. 37pp.
- Dauble, D. D., and R. H. Gray. 1980. Comparison of a small seine and a backpack electroshocker to evaluate nearshore fish population in rivers. *The Progressive Fish-Culturist* 42:93-95.
- Debinski, D. M., and P. F. Brussard. 1994. Using biodiversity data to assess species-habitat relationships in Glacier National Park, Montana. *Ecological Applications* 4:833-843.
- Drayton, B., and R. B. Primack. 1995. Plant species lost in an isolated conservation area in metropolitan Boston from 1894 to 1993. *Conservation Biology* 10:30-39.
- Drost, C. A., and G. M. Fellers. 1996. Collapse of a regional frog fauna in the Yosemite area of the California Sierra Nevada, USA. *Conservation Biology* 10:414-425.
- Fuller, M. R., and J. A. Mosher. 1987. Raptor survey techniques. Pages 37-66 *in* Geron-Pendleton, B. A., B. A. Millsap, K. W. Cline and D. M. Bird, eds. *Raptor management techniques manual*. National Wildlife Federation, Washington, DC.
- Gibbons, J. M., R. D. Semlitsch. 1981. Terrestrial drift fence with pitfall traps: an effective technique for quantitative sampling of animal populations. *Brimleyana* 7:1-6.
- Integrated Taxonomic Information System. 2002. Site updated by US Department of Agriculture. <http://www.itis.usda.gov/> (February 19, 2002).
- Levy, P. S., and S. Lemeshow. 1999. *Sampling of populations: methods and applications*. John Wiley and Sons, New York, NY.
- Mueller-Dombois, D., and H. Ellenberg. 1974. *Aims and methods of vegetation ecology*. John Wiley and Sons, New York, NY.
- National Park Service. 1988. *National Park Service management policies*. Washington, DC.

- National Park Service. 1992. NPS-75: Natural Resources Inventory and Monitoring Guidelines. U.S. Dept. of Interior, National Park Service, Washington, DC.
- National Research Council. 1992. Science and the national parks. National Academy Press, Washington DC.
- Newmark, W. D. 1995. Extinction of mammal populations in western North American national parks. *Conservation Biology* 9:512-526.
- Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. *Condor* 82:309-313.
- Shmida, A. 1984. Whittaker's plant diversity sampling method. *Israel Journal of Botany* 33: 41-46.
- Stohlgren, T. J., M. B. Falkner, and L. D. Schell. 1995b. A modified-Whittaker nested vegetation sampling method. *Vegetatio* 117:113-121.
- Stohlgren, T. J., J. F. Quinn, M. Ruggiero, and G. S. Waggoner. 1995a. Status of biotic inventories in U.S. national parks. *Biological Conservation* 71:97-106.
- Turner, I. M., K. S. Chua, J. S. Y. Ong, B. C. Soong, and H. T. W. Tan. 1995. A century of plant species loss from an isolated fragment of lowland tropical rain forest. *Conservation Biology* 10:1229-1244.
- White, G. C., K. P. Anderson, K. P. Burnham, and D. L. Otis. 1983. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, Los Alamos, NM.

**Appendix A. Summary of abbreviations that appear in the document.**

Abbreviation	Meaning
CAGR	Casa Grande Ruins National Monument
CS	Cospar Slough, adjacent to TUMA
DSCESU	Desert Southwest Cooperative Ecosystem Studies Unit
ES	Extensive survey
FPT	Focal-point transect
GICL	Gila Cliff Dwellings National Monument
GPS	Global positioning system
I&M	Inventory and Monitoring Program
SAGU	Saguaro National Park to include Saguaro East (SAGU E) and Saguaro West (SAGU W)
NPS	National Park Service
SAS	Special area survey
SCR	Santa Cruz River
SODE	Sonoran Desert Network
TONT	Tonto National Monument
TUMA	Tumacacori National Historical Park
UA	University of Arizona
USFWS	United States Fish and Wildlife Service
VCPM	Variable circular-plot method